Original Article

Comparison of the outcome of emergency endotracheal intubation in the general ward, intensive care unit and emergency department

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ABSTRACT

Background: Emergency endotracheal intubations outside the operating room (OR) are associated with high complications. We compare the outcome of emergency endotracheal intubation in the general ward, the intensive care unit (ICU) and the emergency department (ED).
Methods: We retrospectively analyzed adult patients requiring emergency endotracheal intubation that called for anesthesiologists at our tertiary care institution from January 1, 2015 to December 31, 2016. We evaluated the outcomes, including aspiration, hemodynamic collapse, pneumothorax, emergency tracheostomy, and survival to hospital discharge in the general ward, ICU, and ED.
Results: There were 416 non-OR emergency endotracheal intubation calls for the anesthesiologist. Among these areas, the ED had the highest proportion of difficult endotracheal (DET) intubation (n = 144 [80.4%]), followed by the general ward (n = 85 [66.4%]), and then the ICU (n = 65 [59.6%]). The incidence of hemodynamic collapse was higher in the general ward (n = 44 [34.4%]) than the ICU (n = 18 [16.5%]) or the ED (n = 16 [9.0%]). We reported the survival rate of the general ward (55.5%), which was lower than the ICU (63.3%) and the ED (80.4%). Among these locations, the ED had the highest rate of neurologically intact (91%) to hospital discharge, compared to the ICU (56.6%) and the general ward (55%). As for the ED, although there was no difference in survival between non-preventive and preventive intubations, preventive intubations was associated with high neurological intact with hospital discharge.

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Conclusion: Emergency and DET intubation in the general ward and ICU resulted in a higher incidence of hemodynamic collapse and mortality than those performed in the ED. Early calls for the anesthesiologist for DET intubation without medications in the ED resulted in a higher rate of neurologically intact survival to hospital discharge.

At a glance of commentary

Scientific background on the subject

Emergency and difficult endotracheal intubations outside the operating room are associated with high complications. Despite these complications, there have been no studies comparing the outcomes of emergency intubation in the general ward, intensive care unit and emergency department.

What this study adds to the field

Emergency and difficult endotracheal intubation in the general ward and intensive care unit resulted in a higher incidence of hemodynamic collapse and mortality than the emergency department. This study provides the evidence that earlier effective airway management could decrease mortality and neurologically intact survival to discharge.

At an academic medical center, anesthesiologists may be responsible for difficult airway management outside the OR. Compared to elective intubation in the OR, there are unique challenges inherent in airway management in the emergency non-OR setting [1,2]. In the OR, most intubations are performed under elective, controlled conditions by a skilled anesthesiologist who is trained in airway management; therefore, the complication rate is low. In contrast, airway management outside the OR often requires emergency intubation in patients suffering from respiratory failure, shock, or cardiac arrest, with the incidence of DET intubation ranging from 8% to 12% [3–6]. Hypoxemia is likely to be the most common complication and other important complications, such as esophageal intubation, aspiration, and even death may occur [5]. Jaber et al. studied 253 tracheal intubations performed in the ICU of several institutions and reported a 28% incidence of serious life-threatening complications [3]. Outside the OR, the majority of airway management comes from the ED or ICU, as these are the sites that handle the highest volume of patients, especially those with a difficult airway due to maxillofacial trauma, burns, patients with respiratory problems, cardiac problems, and neurological problems [6,7]. Previous studies have shown that in both the ED and ICU environment, tracheal intubation is a high-risk procedure [3,4]. However, in the general ward, a rapid decline in respiratory function also requires emergency tracheal intubation [8]. Despite the high incidence of emergency endotracheal intubation, there have been no recent studies comparing the outcomes of emergency intubation in

these areas. Therefore, the current study was undertaken to compare the outcomes of emergency endotracheal intubation calls for anesthesiologists in the general ward, ICU, and ED in a single medical center.

Material and methods

We retrospectively analyzed all adult patients requiring emergency endotracheal intubation outside the OR that called for the anesthesiologist at our tertiary care institution between January 1, 2015 and December 31, 2016. Patients who were less than 18 years of age or those missing data were excluded from the study. Approval was obtained from the institutional review board (Chang Gung Medical Foundation, Approval number: 201801419B0), and informed consent was waived.

At our institution, all hospitalized patients and patients admitted to the ED were assessed for the reasons for DET intubation. These included head and neck problems (head and neck tumor, surgery, trauma, infection, radiation, burn and oral bleeding), limited mouth opening, short neck, small mandible, morbid obesity, upper airway obstruction (acute epiglottitis), and ankylosing spondylitis. If the patients showed any reasons for difficult intubation, DET was recorded in the electronic medical record homepage and the nursing Kardex [Fig. 1A, B]. When these patients needed to be intubated, the responsible senior resident anesthesiologist (who carries a special phone line for emergency and DET intubation) was called to assist the intubation. Although there were no risk factors, if failed intubation was encountered by the

Remark DET in the electronic medical record homepage

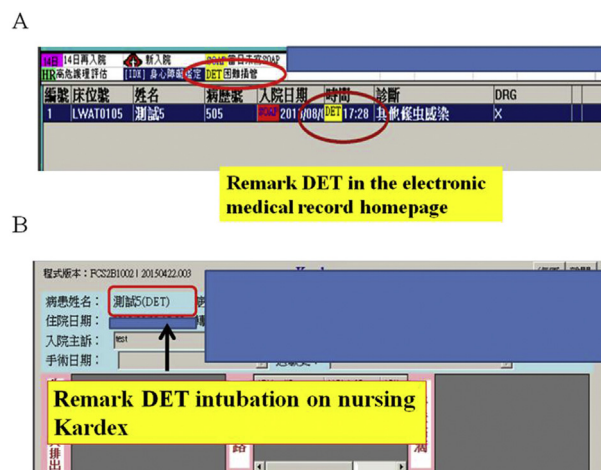Remark DET intubation on nursing Kardex

Fig. 1 Remark DET in the electronic medical record homepage (A) and remark DET intubation on nursing Kardex (B). DET: difficult endotracheal intubation.

Table 1 Patient characteristics and variables requiring emergency endotracheal intubation in different locations.

	All patients (n = 416)	Ward (n = 128)	ICU (n = 109)	ED (n = 179)	p-value	Post-hoc
Age (years), mean (SD)	59.27 ± 15.21	63.67 ± 13.66	62.89 ± 15.16	53.93 ± 14.69	<0.001	W, I > E
Male gender, n (%)	306 (73.6%)	86 (67.2%)	83 (76.1%)	137 (76.5%)	0.145	—
BMI	22.75 ± 4.95	23.38 ± 5.51	22.99 ± 5.04	22.12 ± 4.35	0.084	—
Comorbidities						
Hypertension	161(38.7%)	62(48.4%)	50(45.9%)	49(27.4%)	<0.001	W, I > E
Arrhythmia	17 (4.1%)	8 (6.2%)	8 (7.3%)	1 (0.6%)	0.006	W, I > E
Coronary artery disease	18 (4.3%)	7 (6.4%)	7 (5.5%)	4 (2.2%)	0.178	—
Peripheral vascular disorder	9 (2.2%)	3 (2.3%)	4 (3.7%)	2 (1.1%)	0.348	—
COPD	39 (9.4%)	18 (14.1%)	14 (12.8%)	7 (3.9%)	0.004	W, I > E
CVA/TIA	28(6.7%)	14 (10.9%)	7 (6.4%)	7 (3.9%)	0.053	—
Diabetes mellitus	90 (21.6%)	34(26.6%)	32(17.9%)	24 (22.0%)	0.189	—
Chronic kidney disease	31 (7.5%)	16(12.5%)	10 (9.2%)	5 (2.8%)	0.004	W > E
Charlson comorbidity index	2.69 ± 2.38	3.37 ± 2.52	2.44 ± 2.14	2.35 ± 2.33	<0.001	W > I, E
Time, n (%)						
Day time (08:00–15:59)	179 (43.0%)	58 (45.3%)	62 (56.9%)	59 (33.0%)	0.003	I > W, E
Night (16:00–23:59)	146 (35.1%)	42 (21.8%)	30 (27.5%)	74 (41.3%)		—
Midnight (00:00–07:59)	91 (21.9%)	28 (21.9%)	17 (15.6%)	46 (25.7%)		—
DET intubation, n (%)						
Yes	294 (70.7%)	85 (66.4%)	65 (59.6%)	144 (80.4%)	<0.001	E > W, I
No	122 (29.3%)	43 (33.6%)	44 (40.4%)	35 (19.6%)		W, I > E
Intubation devices						
"Rusch" Flexi-Slip stylet	128 (30.8%)	46 (35.9%)	60 (55.0%)	22 (12.3%)	<0.001	I > W > E
Fiberoptic intubation	261 (62.7%)	67 (52.3%)	39 (35.8%)	155 (86.6%)		E > W > I
Others	27 (6.5%)	15 (11.7%)	10 (9.2%)	2 (1.1%)		W, I > E
Drugs						
Sedation only	19 (4.6%)	12 (9.4%)	3 (2.8%)	4 (2.2%)	<0.001	W > I, E
Muscle relaxant only	38 (9.2%)	23 (18%)	12 (11%)	3(1.7%)		W, I > E
Sedation + muscle relaxant	120 (28.8%)	32 (25%)	59 (54.1%)	29 (16.2%)		I > W, E
None	239 (57.4%)	61 (47.6%)	35 (32.1%)	143 (79.9%)		E > W > I
Indications for intubation						
Respiratory failure	198 (47.6%)	84 (65.6%)	74 (67.9%)	40 (22.3%)	<0.001	W, I > E
Airway protection	171 (41.1%)	23 (18.0%)	19 (17.4%)	129 (72.1%)		E > W, I
ETT change	13 (3.1%)	2 (1.6%)	11 (10.1%)	0 (0%)		I > W, E
Cardiac arrest	34 (8.2%)	19 (14.8%)	5 (4.6%)	10 (5.6%)		W > I, E

Others: Trachway video intubation stylet and lightwand intubation.

Abbreviations: SD: standard deviation; BMI: body Mass Index; DET: difficult endotracheal; ETT: Endotracheal tube; ICU: intensive care unit; ED: emergency department; COPD: chronic pulmonary disease; CVA: cerebrovascular accident; TIA: transient ischemic attack; W: ward; I: ICU; E: ED.

duty doctor, they also called the anesthesiologist to assist intubation. The senior anesthesiologist immediately went to the scene with a fiberscope and a video laryngoscope. The senior resident anesthesiologist had at least three years of intraoperative anesthesiology experience. If he experienced difficulty in airway management, the attending anesthesiologist could request further assistance or call the otolaryngologist (ENT surgeon) for an emergency tracheostomy.

After intubation, the senior resident anesthesiologist recorded baseline characteristics of the patient, comorbidities, date, time, and hospital location of intubation, reason for intubation, difficulty of intubation, and medications used. DET was defined as a patient having any one of the above risk factors and/or grade III or IV laryngoscopy viewed by the responsible resident anesthesiologist. The Charlson Comorbidity Index (CCI) score was used to determine overall systemic health [9]. We also recorded complications including aspiration, severe cardiovascular collapse, pneumothorax, and emergency tracheostomy. Aspiration was defined as an observation by the anesthesiologist of gastric contents at the glottic opening or new infiltration on a chest radiography taken after intubation. Severe cardiovascular collapse was defined as patients with unstable hemodynamics who required introduction of vasopressor support 5–10 min before or during intubation, or cardiac arrest needing resuscitation. Pneumothorax was defined as the presence of air or gas in the pleural cavity, which was diagnosed by chest radiography immediately after intubation. Composite complication was defined as the presence of either hemodynamic collapse, aspiration, pneumothorax, or emergency tracheostomy.

All patients were followed until death or discharge from the hospital. Patients' outcomes were extracted from the medical records. The outcome was evaluated by any complications, survival, and cerebral performance category (CPC) when discharged from hospital. The five categories of CPC include: CPC 1, conscious and alert with good cerebral performance; CPC 2, conscious and alert with moderate cerebral performance; CPC 3, conscious with severe cerebral disability; CPC 4, comatose or in persistent vegetative state; CPC 5, brain dead, circulation preserved [10]. According to the definition of

Table 2 Reasons for emergency endotracheal intubation in different locations.

	Total (n = 416)	Ward (n = 128)	ICU (n = 109)	ED (n = 179)
Head and neck problems	242 (58.2)	61 (47.6%)	44 (40.3%)	137 (76.5%)
Morbid obesity	5 (1.2%)	3 (2.3%)	2 (1.8%)	0 (0%)
Mouth opening limited	8 (1.9%)	1 (0.8%)	2 (1.8%)	5 (2.8%)
Short neck	11(2.6%)	3 (2.3%)	5 (4.5%)	3 (1.6%)
Small mandible	4(1%)	2 (1.6%)	2 (1.8%)	0 (0%)
Upper airway obstruction	46(11.0%)	8 (6.2%)	11 (10%)	27 (15%)
Ankylosing spondylosis	3(0.7%)	3 (2.3%)	0 (0%)	0 (0%)
Nil	97(23.3%)	47 (36.7%)	43 (39.4%)	7 (3.9%)

Data are given as number (percentage) of each group. ICU: intensive care unit; ED: emergency department.

CPC, CPC 1 and 2 were classified as normal or mild neurological deficit, CPC 3 was defined as moderate neurological deficit, or CPC 4 and 5 were defined as severe neurological deficit.

Statistical analysis

All data were entered into a Microsoft Excel (Microsoft Corp., Redmond, WA) spreadsheet and analyzed statistically using SPSS version 20.0 (SPSS Inc., Troy, NY).

Categorical data were analyzed using the Chi-square test or Fisher's exact test, and continuous data by one-way analysis of variance. Post-hoc Scheffé test was performed to investigate the mean differences between groups when significance for continuous data. To determine which groups are different from the others, Bonferroni Test was performed as the post hoc test for categorical data. For this purpose, the process would be to conduct each of the 3 paired comparisons (3 × 2 contingency table is cutting into modified 2 × 2 contingency table) and the new significant level would become 0.05/3 = 0.016 [11]. In Tables 1 and 3, we performed a chi-square test for each of 3 paired comparisons (i.e. cross tabs multiple comparison) by SPSS version 20.0. SPSS offers Bonferroni-adjusted significance tests for pairwise comparisons and will automatically adjust the significance values. The log-rank test was used for comparison of the Kaplan–Meier curves among the three groups. A p-value less than or equal to 0.05 was considered to be statistically significant.

Results

After exclusion, there were 416 non-OR emergency endotracheal intubation that called for the anesthesiologist during the two-year period. Table 1 summarizes patients' baseline characteristics and the results of the univariable analysis between the different locations. Compared to the general ward and ICU (63.67 ± 13.66 or 62.89 ± 15.16 years, respectively), patients from the ED were slightly younger (53.93 ± 14.69 years). Gender and BMI of the patients were not significantly different between the general ward, ICU, and ED. The proportion of hypertension, chronic kidney disease, and the total CCI score were higher in the general ward than in the ICU and ED. However, the total CCI was not different between the ICU and ED. Most emergency endotracheal intubation calls in the ICU occurred during day shifts. There were no statistically difference between these locations during night and midnight.

Devices and difficulty of intubation

Of the 416 patients, 294 (70.7%) were recognized as DET intubation by the senior resident anesthesiologist and 122 (29.3%) patients were not difficult to intubate. Among the three areas, the ED had the highest proportion of DET intubation (n = 144 [80.4%]), followed by the general ward (n = 85 [66.4%]), and then the ICU (n = 65 [59.6%]). Fiberoptic intubation was mostly performed in the ED (n = 155 [86.6%]) and the "Rusch" Flexi-Slip stylet was mostly used in the ICU (n = 60 [55%]) [Table 1].

Medications used for endotracheal intubation

In the general ward, 12 (9.4%) patients received sedative for intubation, 23 (18%) patients received muscle relaxant only, and 32 (25%) received both sedation and muscle relaxant to facilitate intubation. In the ICU, 3 (2.8%) patients received sedation only, 12 (11%) patients received muscle relaxant only, and 59 (54.1%) received both sedation and muscle relaxant to facilitate intubation. In the ED, among 179 patients, 143 (79.9%) did not receive any medication for intubation [Table 1].

Indications for intubation

The most frequent indication for intubation in all patients was respiratory failure (n = 198 [47.6%]), followed by airway protection (n = 171 [41.1%]), cardiac arrest (n = 34 [8.2%]), and

Table 3 Complications of emergency endotracheal and DET intubation in different locations.

Complications	All emergency intubation (n = 416)	Emergency intubation in ward (n = 128)	Emergency intubation in ICU (n = 109)	Emergency intubation in ED (n = 179)	p-value	Post-hoc
Hemodynamic collapse	78 (18.8%)	44 (34.4%)	18 (16.5%)	16 (9.0%)	<0.001	W > I, E
Aspiration	14 (3.4%)	4 (3.1%)	2 (1.6%)	8 (4.5%)	0.477	—
Pneumothorax	1 (0.2%)	0 (0%)	0 (0%)	1 (0.6%)	0.515	—
Emergent tracheostomy	4 (1.0%)	0 (0%)	2 (1.8%)	2 (1.1%)	0.339	—
Composite complications	84 (20.19%)	44 (34.4%)	18 (16.5%)	22 (12.3%)	<0.001	W > I, E

Data are given as number (percentage) of each group. Abbreviations: DET: difficult endotracheal; ICU: intensive care unit; ED: emergency department; W: ward; I: ICU; E: ED.
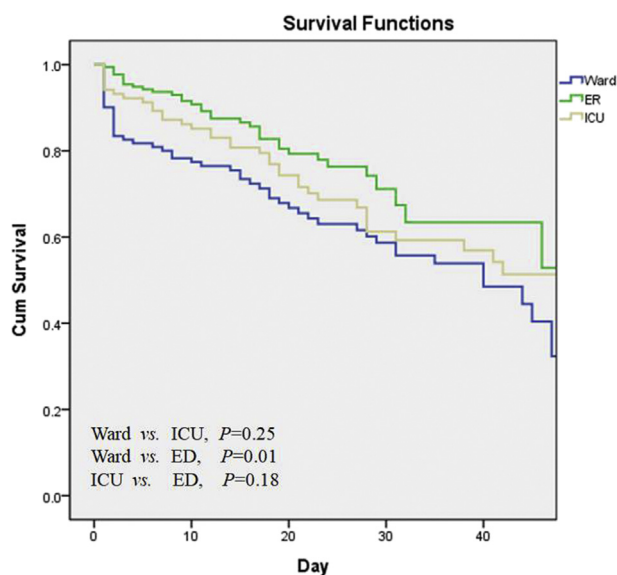
Fig. 2 Kaplan–Meier survival curve of emergency endotracheal intubations in the different locations. ICU: intensive care unit; ED: emergency department.

endotracheal tube (ETT) change (n = 13 [3.1%]). In the general ward and ICU, respiratory failure was the most frequent indication for intubation (n = 84 [65.6%] and n = 74 [67.9%], respectively), followed by airway protection (n = 23 [18%] and n = 19 [17.4%], respectively). However, in the ED, the most frequent indication for intubation was airway protection (n = 129 [72.1%]), followed by respiratory failure (n = 40 [22.3%]) [Table 1].

Reasons for emergency endotracheal intubation

Table 2 lists the reasons for emergency endotracheal intubation in the different locations. The ED had the highest number of head and neck problems (76.5%), compared to the general ward (47.6%), and the ICU (40.3%). However, the general ward (36.7%) and ICU (39.4%) had the higher number of patients with no risk factor, compared to ED (3.9%).

Outcome of emergency endotracheal intubation

Of all 416 patients, 84 (20.19%) patients presented composite complications, including aspiration, hemodynamic collapse, pneumothorax, and emergency tracheostomy [Table 3].

Aspiration was not significantly different between the general ward (n = 4 [3.1%]), ICU (n = 2 [1.6%]) and ED (n = 8 [4.5%]) [Table 3]. However, the incidence of hemodynamic collapse was higher in the general ward (n = 44 [34.4%]) than the ICU (n = 18 [16.5%]) and the ED (n = 16 [9.0%]). Only one patient from the ED presented pneumothorax in the chest radiography taken immediately after intubation. Four surgical airways — two patients in the ED and two in the ICU — were performed as a result of failed intubation. One patient from the ED experienced severe airway stenosis due to a vocal cord tumor, and the other could not be intubated due to recent buccal cancer and flap reconstruction with uncontrolled bleeding. For the surgical airways in the ICU, one patient experienced an unexpected large epiglottic cyst and the other had a short neck and small mandible with airway edema. Among them, three cases were discharged without any sequelae except tracheostomy and one case was expired.

In this study, we excluded the cases of preventive tracheal intubation (awake fiberoptic intubation by anesthesiologist without any medications) and analyzed their outcomes in different locations. The results are listed in Supplemental Table 1. Incidence of hemodynamic collapse was higher in the general ward (n = 26 [38.8%]) than the ICU (n = 13 [17.6%]) and ED (n = 5 [8.3%]). We also compared and analyzed the outcomes of preventive intubation and non-preventive intubations in ED. The incidence of complications was not significantly different between the two groups [Supplemental Table 3].

Survival analysis and CPC score

Figure 2 shows the Kaplan–Meier survival curve of all emergency endotracheal intubations in the different locations. Patients in the general ward had a lower survival rate than the ED (p = 0.01) during follow-up after intubation. No significant difference was observed between the general ward and the ICU (p = 0.25) or the ICU and the ED (p = 0.18) during the follow-up period. Table 4 shows survival and the CPC score of emergency endotracheal and DET intubation. Overall, 284 (68.3%) cases survived to discharge from hospital. Among those, 209 (73.6%) patients were discharged from the hospital with CPC scores of 1 or 2, 57 (20.1%) with CPC score of 3, and 18 (6.3%) with CPC scores of 4 or 5. In these different locations, we found that the ED had a higher rate of intact neurological survival to hospital discharge, of which 91% had CPC scores of 1 or 2, compared to 56.6% for the ICU and 55% for the general ward.

Table 4 Survival and CPC of patients from different locations when discharged from hospital.						
	Total	Ward	ICU	ED	p-value	Post-hoc
Survive	284 (68.3%)	71 (55.5%)	69 (63.3%)	144 (80.4%)	<0.001	E > W, I
CPC category when discharge − No./total No. (%)						
1 and 2	209/284 (73.6%)	39/71 (55%)	39/69 (56.5%)	131/144 (91%)	<0.001	E > W, I
3	57/284 (20.1%)	24/71 (33.8%)	25/69 (36.2%)	8/144 (5.6%)		W, I > E
4 and 5	18/284 (6.3%)	8/71 (11.3%)	5/69 (7.2%)	5/144 (3.5%)		−

Data are given as number (percentage) of each group. Abbreviations: ICU: intensive care unit; ED: emergency department; CPC: Cerebral Performance Category; W: ward; I: ICU; E: ED.

We also excluded the cases of preventive tracheal intubation and analyzed the survival and CPC of patients when discharged from the hospital in different locations. There was a trend of higher survival rate in the ED ($p = 0.077$). Among those, 59 (52.7%) patients were discharged from the hospital with CPC scores of 1 or 2, 40 (35.7%) with a CPC score of 3, and 13 (11.6%) with CPC scores of 4 or 5. The ED had a higher intact neurological survival to hospital discharge, of which 78.6% had CPC scores of 1 and 2, compared to 46.8% for the ICU, and 40.5% for the general ward [Supplemental Table 2]. We also compared and analyzed the rate of survival and CPC score for preventive intubation and non-preventive intubation in the ED. The survival rate was not significantly different between non-preventive and preventive intubations (n = 28 [77.8%] vs. n = 116 [81.1%], $p = 0.94$). However, a higher intact neurological survival to hospital discharge was seen in preventive intubation, where 94% of CPC scores were 1 and 2, compared to non-preventive intubation, where 78.6% of CPC scores were 1 and 2 [Supplemental Table 4].

Discussion

To our knowledge, this is the first study to compare the outcomes of emergency endotracheal intubation outside the OR in different locations. Our results showed that the ED had the highest proportion of DET intubation, and they were mostly performed using fiberoptic intubation. Moreover, patients from the ED had a lower incidence of complications and higher rate of intact neurological survival to hospital discharge.

The incidence of difficult airway in the ED was understandably high, as there were a disproportionately larger number of patients requiring airway management as a result of acute medical or surgical conditions, which by themselves contribute to the difficulty [7]. In addition, airway management in the ED often occurs in an unpredictable and uncontrolled environment, sometimes with the patient arriving unannounced [7]. The unique situation of having a high proportion of difficult airways and an unpredictable environment affords the emergency physician the opportunity to become an expert in emergency and difficult airway management. Therefore, most emergency intubations were successfully managed by the emergency physician [7]. They called an anesthesiologist to assist intubation when they encountered a truly difficult airway. However, doctors in the general ward and the ICU have less experience in intubation [6,8]. They look to an anesthesiologist to assist with intubation, and not all of them are difficult to intubate. We observed this trend in our study; more than 80% of patients in ED were true DET intubation and 86.6% of patients needed fiberoptic endotracheal intubation by an anesthesiologist. However, in the general ward and ICU, more than 30% of cases were not true DET intubation.

Use of muscle relaxants during emergency airway management varies widely among institutions. Schwartz et al. [5] reported the use of muscle relaxants in 80% of intubations, but Mort [4] used muscle relaxants in only 20% of intubations. Anesthesia teaching discourages the use of muscle relaxants due to the fear of being unable to intubate and ventilate a paralyzed patient [12]. In contrast, in the ED, rapid sequence intubation (RSI) had decreased the rate of complications during emergency intubation and is considered safe [13–15]. Although RSI is generally the preferred approach in the ED, it may be poorly suited for some patients with difficult airway attributes. A careful assessment of airway difficulty must precede the decision to use RSI [14,16,17]. In our institution, patients from the ED had to be assessed for the risk factors for DET intubation. If they presented these risk factors, the senior resident anesthesiologist was called without administration of muscle relaxant. Most patients in the ED (80%) were intubated without any medication. In our study, in the general ward and ICU, muscle relaxants were used to facilitate 42.9% and 65.1% of intubations, respectively. Although the anesthesiologist acknowledged that muscle relaxants may be harmful in difficult intubation, it is difficult to awake intubation in the emergency setting with hypoxia, especially in critically ill patients in the general ward and ICU.

Recently, with the introduction of the true antagonist sugammadex, the condition of 'can't intubate, can't ventilate' (CICV) can be easily resolved, and the use of muscle relaxants is more open. Sugammadex is a modified γ-cyclodextrin that rapidly and completely reverses the neuromuscular block associated with rocuronium [18]. Recently, the benefits of sugammadex have been widely discussed, often focusing on its use in the unanticipated difficult airway where it might be helpful as a rescue in a CICV scenario [19,20]. A previous study also demonstrated that sugammadex was suggested as a rescue drug in a CICV scenario after administration of rocuronium [20]. However, a case illustrated that sugammadex, while completely reversing rocuronium-induced neuromuscular block, did not rescue a CICV situation, where airway instrumentation has led to airway swelling [21]. Therefore, we suggested that if sugammadex is part of a rescue management plan, it should be used early in the management of the difficult airway situation before repeated airway manipulations.

In this study, 13 (3.1%) patients were indicated for changing the endotracheal tube due to cuff rupture or sputum impaction. Exchanging the endotracheal tube in the high-risk patient is challenging and life-threatening. Endotracheal tube exchange is a simple procedure for the anesthesiologist in the OR. However, it is not available outside the OR in our institute. Additionally, lack of experience of the operator may also pose risks of complications, such as hypoxemia, esophageal intubation, and loss of airway [22]. It is reasonable to simply extubate and reintubate the patient outside the OR to avoid the risks associated with airway exchange catheters.

In this study, the overall complication rate was 20.19%. The most frequent complication was hemodynamic collapse, with 34.4% occurrence in the general ward, 16.5% in the ICU, and 9.0% in the ED. A multicenter study of emergency nonoperative intubation in the, ICU reported a 28% incidence of overall complication, with 25% hemodynamic collapse [3]. Also, previous literature has demonstrated that complications may occur in up to 40% of cases, with severe complications around 24% in critically ill patients [23]. In an analysis of 13 ED centers with 17,583 emergency intubations, the incidence of hypotension and cardiac arrest was 24.6% [24]. The incidence of hemodynamic collapse in emergency intubation in the general ward compared to the ICU and ED was not reported. In

recent literature, hemodynamic outcome data has been excluded because it is difficult to distinguish airway-related hemodynamic perturbations from underlying pathophysiologic states, given the clinical situation being evaluated [25]. Although it is difficult to clearly distinguish cause from effect, it was an important complication in emergency intubation. The increased number of attempts of emergency or DET intubation will increase the incidence of hemodynamic collapse. In this study, we collected the data of hemodynamic collapse. Although we cannot compare the incidence of hemodynamic collapse in the general ward, the outcome of hemodynamic collapse in the ICU and ED was lower than that reported in the literature.

The incidence of hemodynamic collapse was higher in the general ward and the ICU when compared to the ED. There were several possible reasons for the high rate of hemodynamic collapse in these areas. Most of the patients in these two areas were critically ill, compared to those in the ED [3,5,7,23]. Furthermore, operator-related factors also influenced complications [26]. Operator-related factors included the level of experience and training of the operator [27]. In the ED, intubations were performed by an attending physician, whereas in our institution, intubations in the general ward and the ICU were performed by a resident. The literature reports that the intubation success rate improves with advanced training [25]. In addition, in our study, most patients in the ED were high-risk for DET intubation, and the anesthesiologist was called as soon as patients needed intubation. The literature reports an increased rate of airway-related or hemodynamic complications with two or more attempts at intubation [4,23]. In the general ward and the ICU, not all patients for whom the anesthesiologist was called were true DET intubation cases. The doctors tried two or more attempts themselves if patients had no risk factor for DET intubation and called the anesthesiologist only when intubation failed. Therefore, the incidence of hemodynamic collapse was high in the general ward and ICU compared to the ED.

Reported airway-related complication rates were quite varied among institutions. In a study of urgent tracheal intubation in general hospital units, the complication rate was 27% [8]. The most common complications were esophageal intubation (9%) and aspiration (around 7%). In a study on ICUs, esophageal intubation was 7.4% and aspiration was 5.9% [23]. In 3423 emergency non-OR airway management cases, the incidence of aspiration was 2.8%; esophageal intubation was 1.3%; dental injury was 0.2%; pneumothorax was 0.1% [25]. This wide range of complications reflected variations in practice patterns, outcome definitions, and data collection methods among institutions [3,5,7]. In most studies, aspiration was defined as immediate peri-induction observation of gastric contents at the glottic opening or in the endotracheal tube [25]. In our study, aspiration was defined, in addition to the observation of gastric contents at the glottic opening or in the endotracheal tube, as being diagnosed by a radiologist in chest radiography taken after intubation. In our study, the incidence of aspiration occurred in 3.1% of cases in the general ward, 1.6% of cases in the ICU, and 4.5% of cases in the ED. Given the increased incidence of difficult intubation in the ED,

and frequent blood, vomitus or secretions in the airway, the incidence of aspiration was slightly higher than in the general ward and ICU. Compared to other studies, we observed a decreased aspiration rate in our study. However, we have no data about esophageal intubation and dental injury; therefore, we cannot compare these conditions with other studies. An assessment of the risk factors for DET intubation, and an immediate call for the anesthesiologist with advanced airway equipment and not attempting to intubate, will lower the incidence of hemodynamic collapse and aspiration.

We reported 31.7% of overall in-hospital mortality, within which the mortality rate of the general ward (44.5%) was higher than the ICU (36.7%), and the ED (19.6%). In the general ward, 71 (55.5%) patients survived to discharge. A study reported a 48% overall mortality rate for patients who underwent emergency intubation in general hospital units. Only 17% of patients intubated in general hospital units were discharged home [8]. Compared to this study, in-hospital mortality was similar, but a higher percentage of patients in our study were discharged home. Mortality in the ICU was similar to another study [28]; 56.5% of patients survived to discharge home in our study. In a study reporting a mortality rate of 27% after intubation in an ED, 43.6% of patients were discharged home and 25.8% of patients were discharged to a skilled nursing facility [29]. The influences of comorbidities on mortality during emergent and DET intubation is still unknown. The higher mortality rate in the general ward seems to be associated with a higher CCI score. However, the CCI score was not different between the ICU and the ED, and the survival rate was lower in the ICU than in the ED. Future prospective studies are needed to evaluate the impact of comorbidities on the outcome during emergent and DET intubation. In our study, we found that the ED had a higher rate of survival to hospital discharge with a higher rate of neurologically intact compared to the general ward and the ICU. Emergency and DET intubation performed by an expert operator was associated with good prognosis than intubations performed by non-experts. As for the ED, although there was no difference in the survival rate between preventive and non-preventive intubation, preventive intubation was associated with high neurologically intact with hospital discharge. Assessment of the risk factors for DET intubation, and early calls for the anesthesiologist to assist intubation without medications, could improve neurologically intact survival to discharge.

Like any trial, there are a number of limitations here. First, this was a study from a single center, and this must be considered when extrapolating the results to other clinical settings. Incorporating a multicenter study in the future could further validate these findings. Second, this was a retrospective study. Procedural complications and details of the intubation procedure were collected by the anesthesiologists, and the possibility of imperfect documentation and underreporting of complications must be considered. In addition, complications such as esophageal intubation, dental injury, and trauma were not documented, and their inclusion may have improved the study.

Despite these limitations, our study offers an insight into DET intubation in the general ward, the ICU, and the ED.

Conclusion

In conclusion, emergency and DET intubation performed by an expert operator in the ED was associated with fewer complications and lower mortality than intubations. Emergency and DET intubation in the general ward and the ICU resulted in a higher proportion of hemodynamic collapse and mortality than those performed in the ED. Early calls for the anesthesiologist for DET intubation without medications in the ED resulted in a higher rate of neurologically intact survival to hospital discharge. It has been suggested that earlier effective airway management could decrease mortality and neurologically intact survival to discharge.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bj.2020.07.006.

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