Cardiac Arrest and Mortality Related to Intubation Procedure in Critically Ill Adult Patients

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Cardiac Arrest and Mortality Related to Intubation Procedure in Critically Ill Adult Patients: A Multicenter Cohort Study

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Objectives: To determine the prevalence of and risk factors for cardiac arrest during intubation in ICU, as well as the association of ICU intubation–related cardiac arrest with 28-day mortality.
Design: Retrospective analysis of prospectively collected data.
Setting: Sixty-four French ICUs.
Patients: Critically ill patients requiring intubation in the ICU.
Interventions: None.
Measurements and Main Results: During the 1,847 intubation procedures included, 49 cardiac arrests (2.7%) occurred, including 14 without return of spontaneous circulation (28.6%) and 35 with return of spontaneous circulation (71.4%). In multivariate analysis, the main predictors of intubation-related cardiac arrest were arterial hypotension (systolic blood pressure < 90 mm Hg) prior to intubation (odds ratio = 3.406 [1.797–6.454]; $p = 0.0002$), hypoxemia prior to intubation (odds ratio = 3.991 [2.101–7.583]; $p < 0.0001$), absence of preoxygenation (odds ratio = 3.584 [1.287–9.985]; $p = 0.0146$), overweight/obesity (body mass index > 25 kg/m^2; odds ratio = 2.005 [1.017–3.951]; $p = 0.0445$), and age more than 75 years old (odds ratio = 2.251 [1.080–4.678]; $p = 0.0297$). Overall 28-day mortality rate was 31.2% (577/1,847) and was significantly higher in patients who experienced intubation-related cardiac arrest than in noncardiac arrest patients (73.5% vs 30.1%; $p < 0.001$). After multivariate analysis, intubation-related cardiac arrest was an independent risk factor for 28-day mortality (hazard ratio = 3.9 [2.4–6.3]; $p < 0.0001$).
Conclusions: ICU intubation–related cardiac arrest occurs in one of 40 procedures with high immediate and 28-day mortality. We identified five independent risk factors for cardiac arrest, three of

which are modifiable, possibly to decrease intubation-related cardiac arrest prevalence and 28-day ICU mortality. (*Crit Care Med* 2018; 46:532–539)

Key Words: airway; cardiac arrest; critical care; intubation; mechanical ventilation

Intubation is one of the most commonly performed high-risk procedures (1) in ICUs (2). Severe hypoxemia, cardiovascular collapse, and difficult intubation are the most frequent intubation-related complications (2–4). To prevent and limit the prevalence of severe hypoxemia and severe collapse following the intubation procedure and associated complications, specific risk factors for complications related to intubation (3) and difficult intubation in the ICU (2) have been identified and several preoxygenation techniques and intubation algorithms have been developed (5–8).

However, intubation-related cardiac arrest in critically ill adult patients has been less studied (2, 3, 7, 9–12). Studies published so far were not adequately powered to evaluate this outcome and were rather focused on severe hypoxemia and/or severe collapse related to intubation (2–4). One retrospective study (13) did assess the prevalence and etiology of cardiac arrests during emergency intubation outside the operating room. However, the studied intubation procedures were not performed only in the ICU (26/60), but also outside the ICU (34/60), in wards or emergency departments, and patient or procedure characteristics recorded prior to intubation were not assessed.

To our knowledge, there is no recent prospective study which specifically analyzed the risk factors for ICU intubation procedure–related cardiac arrest.

The main objectives of our study were to establish the prevalence of cardiac arrest during the intubation procedure, the mortality rate of patients suffering cardiac arrest, immediately and at day 28, and to assess the risk factors for cardiac arrest and 28-day mortality in a large cohort of ICU intubation procedures. We hypothesized that intubation-related cardiac arrest is not uncommon and is associated with high morbidity and mortality and that potentially modifiable risk factors could be identified.

MATERIALS AND METHODS

Setting and Study Design

We retrospectively analyzed data from intubation procedures collected in six prospective randomized and observational studies using five databases (2–4, 6, 8, 14), in 64 ICUs overall. For each study, similar data were collected before, during, and after intubation procedures using the same methodology. Institutional Review Board approval was obtained for each study. Detailed information is available in **Supplemental Table 1** (Supplemental Digital Content 1, http://links.lww.com/CCM/D120).

Inclusion and Exclusion Criteria

All intubation procedures performed in ICU were included for patients 18 years old and older. Patients admitted for cardiac arrest or intubated for cardiac arrest were excluded from the analysis.

Definitions and Outcome Measures

The primary outcome was intubation-related cardiac arrest. Cardiac arrest was defined as asystole, bradycardia, or ventricular dysrhythmia with nonmeasurable blood pressure during or within 5 minutes after intubation, requiring cardiopulmonary resuscitation (13). Secondary outcomes were cardiac arrest without return of spontaneous circulation (ROSC), severe and moderate complications related to intubation, and long-term outcome (mortality rate of patients suffering from cardiac arrests at day 28, length of stay in ICU). Severe complications were defined as follows: severe hypoxemia (defined by saturation nadir < 80%, or decrease in saturation > 10% in case of maximal saturation before intubation < 90%), severe cardiovascular collapse (defined as systolic blood pressure [SBP] < 65 mm Hg recorded at least once or < 90 mm Hg lasting 30 min despite 500–1,000 mL of fluid loading [crystalloid solutions] or decrease of SBP > 20% if < 65 mm Hg before intubation or requiring introduction or increasing doses by > 30% of vasoactive support), cardiac arrest, and death during intubation (cardiac arrest without ROSC) (2, 3, 8). Moderate complications were defined as follows: difficult intubation (> 2 attempts), severe ventricular or supraventricular arrhythmia requiring intervention, esophageal intubation, agitation, pulmonary aspiration, and dental injuries (2, 3, 8).

Patient, Provider, and Practice Characteristics

Patient baseline characteristics were recorded: demographic and epidemiologic data (age, sex, body mass index [BMI]), severity scores (Simplified Acute Physiologic Score [SAPS] II at admission, Sequential Organ Failure Assessment [SOFA] score on the day of the procedure), type of admission, reason for ICU admission, indication for intubation procedures, comorbidities, information given to the patient concerning intubation procedure, presence of nasogastric tube prior to intubation procedure, lowest peripheral capillary oxygen saturation (SpO_2) prior to intubation procedure (hypoxemia prior to intubation was defined as a SpO_2 nadir < 80%, regardless of oxygen flow rate, during the 4 hr preceding intubation), lowest SBP prior to intubation procedure (arterial hypotension was defined as SBP < 90 mm Hg), presence of vasopressor drugs, and existence of predictive criteria of difficult intubation evaluated by the Mallampati score III or IV, obstructive sleep apnea syndrome, reduced mobility of cervical spine, limited mouth opening, coma, severe hypoxia, nonanesthesiologist as operator (MACOCHA) score (2). Provider and practice characteristics were recorded. During the intubation procedure, data were collected for preoxygenation, noninvasive ventilation (NIV) use for preoxygenation, hypnotic and neuromuscular blocker use, number of operators and attempts, Cormack grade, traction force on the laryngoscope, difficult intubation (> 2 attempts), and capnography use.

Power and Sample Size

Power calculation was performed a priori to ensure that the study would be sufficiently powered to detect clinically important differences in exposure variables (15), assuming a power of 0.80, a significance level of 0.05, 2.4% prevalence of primary outcome (2), and an estimated available sample size of 1,847 in the five studies. With a two-sided *t* test, we would be able to detect an absolute difference of greater than or equal to 5.1% in primary outcome (cardiac arrests during intubation procedure) between exposure and nonexposure groups for exposure prevalence ranging from 10% to 50% (15).

Data Analysis

Quantitative variables were expressed as means (SD) or medians (interquartile ranges, 25–75%) and compared using the student *t* test or the Wilcoxon test as appropriate (Gaussian or non-Gaussian variables) between patients who presented with cardiac arrest (cardiac arrest group) and those who did not present with cardiac arrest (no cardiac arrest group). Qualitative variables were expressed as numbers (percentage) and compared using the chi-square test or the Fisher test, as appropriate. First, to search for risk factors of intubation-related cardiac arrest, a multivariate logistic regression was performed. Interactions between variables were tested. All patient, provider, and practice characteristics with *p* value of less than 0.20 in the univariate analysis were entered into the model, and a stepwise procedure was used to select the final model. The Hosmer-Lemeshow test was used to assess the goodness of fit of the logistic model (16). Area under the receiver operating curve (ROC) curve of the final model was assessed, and 2,000 bootstrapped samples were used for internal validation (17). Second, sensitivity analyses were computed, through other multivariate final models, forcing the following variables: first intubation and difficult intubation in the second model (2, 4), and nature of hypnotic used, use of neuromuscular blockers and fluid loading in the third model (4), and emergency degree of intubation (real vs deferred or relative) in the fourth model. Third, we compared cardiac arrests with ROSC to cardiac arrests without ROSC to assess specific risk factors for death (i.e., cardiac arrest without ROSC) subsequent to cardiac arrest. Finally, a Kaplan-Meier analysis was performed to determine the survival for 28-day survival, and a log-rank test was used to compare the two curves (cardiac arrest vs no cardiac arrest). Hazard ratios (HRs) of mortality between cardiac arrest and no cardiac arrest patients were obtained by the Cox method. Then a multivariate analysis using a Cox model was performed to determine the independent factors associated with 28-day mortality. All patient, provider, and practice characteristics with *p* value of less than 0.20 in the univariate analysis were entered into the model, and a stepwise procedure was used to select the final model. The statistical analysis was done with the help of a statistical software (SAS, version 9.3; SAS Institute, Cary, NC). A *p* value of less than 0.05 was considered significant.

RESULTS

Prevalence of Intubation-Related Cardiac Arrest

A total of 1,918 intubation procedures were reported from the five datasets in 64 ICUs from January 2001 to January 2016, after removing duplicates. After exclusion of cardiac arrests as a reason for admission and/or intubation, 1,847 intubations were included (**Fig. 1**). Forty-nine intubation-related cardiac arrests were recorded (2.7% 95% CI [2.0–3.4]).

Patient, Provider, Practice Characteristics

Patient baseline, provider, and practice characteristics are described in **Table 1**. The most common indications for intubation procedures were acute respiratory failure (*n* = 719; 39%) and coma (*n* = 342; 21%). Anesthesiologists were the first providers in 68%, and neuromuscular blockade was used in 80% of intubation procedures (73% succinylcholine, 11% rocuronium, and 15% other neuromuscular blockers).

Factors Associated With Intubation-Related Cardiac Arrest

Based on the univariate analysis (Table 1; and **Supplemental Table 2,** Supplemental Digital Content 1, http://links.lww.com/CCM/D120), SOFA score, BMI, age more than 75 years old, shock as a reason for ICU admission or for intubation, alcohol abuse, low SBP prior to intubation, hypoxemia prior to intubation, first intubation, intubation in real emergency, presence of nasogastric tube, absence of use of hypnotics for induction, MACOCHA

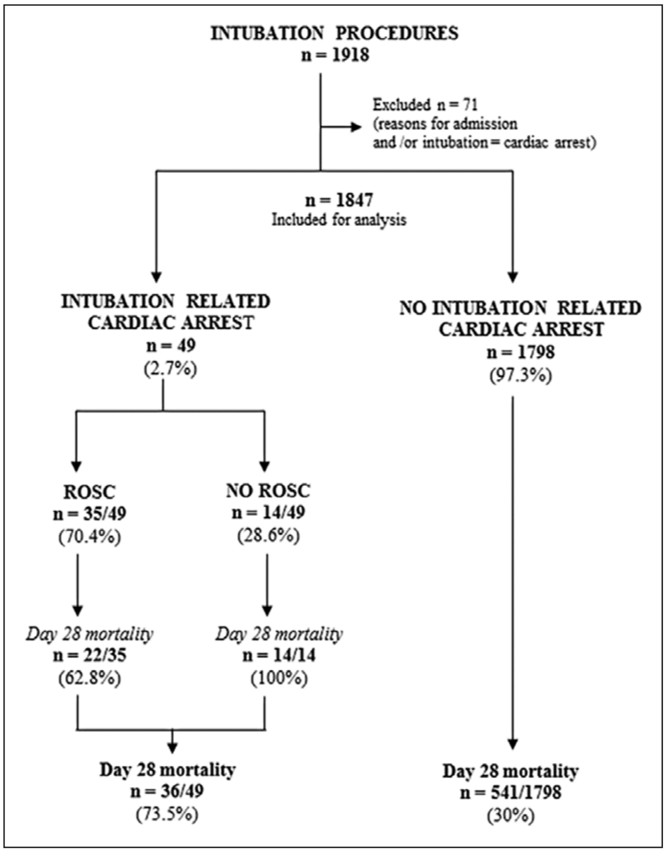

Figure 1. Flow chart of the study. One-thousand nine-hundred eighteen intubation procedures from five studies were included: De Jong et al (2), Jaber et al (3), Jaber et al (8), De Jong et al (6), and Baillard et al (14). After excluding patients with cardiac arrest at admission or at the beginning of intubation, 1,847 intubation procedures were included. Among them, 49 were complicated by cardiac arrests (35 with return of spontaneous circulation [ROSC] and 14 with no ROSC).

TABLE 1. Patient Baseline, Provider, and Practice Characteristics

Characteristics	Overall (n = 1,847)	Intubation-Related Cardiac Arrest (n = 49)	No Intubation-Related Cardiac Arrest (n = 1,798)	p
Age (yr), median (25–75% IQR)	62 (50–73)	67 (55–78)	62 (50–73)	0.077
Age > 75 yr, n (%)	257 (14)	12 (24)	245 (14)	0.030
Male gender, n (%)	1,192 (65)	33 (67)	1,159 (65)	0.677
Simplified Acute Physiologic Score II score, median (25–75% IQR)	47 (36–61)	56 (37–73)	47 (35–60)	0.103
Sequential Organ Failure Assessment score, median (25–75% IQR)	6 (3–8)	8 (5–10)	5 (3–8)	0.039
BMI (kg/m^2), median (25–75% IQR)	25 (22–29)	27 (23–29)	25 (21–29)	0.039
BMI > 25 kg/m^2, n (%)	856 (46)	29 (59)	827 (46)	0.068
Reasons for intubation, n (%)				
Coma	338/1,543 (22)	7/35 (20)	331/1,508 (22)	0.783
Acute respiratory failure	719/1,612 (45)	19/40 (48)	700/1,572 (45)	0.709
Shock	240/1,596 (15)	14/36 (39)	226/1,560 (14)	< 0.001
Extubation failure	209/1,543 (14)	2/35 (6)	207/1,508 (14)	0.216
Others	141/1,595 (9)	2/36 (6)	139/1,559 (9)	0.765
Lowest Spo_2 before intubation, median (25–75% IQR)	82 (61–89)	62 (61–81)	82 (65–89)	0.004
Spo_2 < 80%, n (%)	411 (22)	22 (45)	389 (22)	< 0.001
Vasopressor use, n (%)	550/1,786 (30)	14/48 (29)	333/1,738 (19)	0.084
Lowest SBP before intubation, median (25–75% IQR)	98 (78–120)	87 (65–105)	110 (89–130)	< 0.001
SBP < 90 mm Hg, n (%)	442 (24)	23 (47)	419 (23)	< 0.001
First intubation, n (%)	1,175/1,715 (69)	40/48 (83)	1,135/1,667 (68)	0.025
Anesthesiologist, n (%)	1,225/1,773 (68)	32/48 (67)	1,196/1,725 (69)	0.693
Use of hypnotic for induction, n (%)	1,688 (91)	39 (80)	1,646 (91)	0.004
Nesdonal	43 (2)	1 (2)	42 (2)	1.000
Propofol	298 (16)	6 (12)	292 (16)	0.453
Etomidate	766 (41)	18 (37)	748 (42)	0.495
Ketamine	502 (27)	11 (22)	491 (27)	0.450
Others	79 (5)	3 (6)	73 (4)	0.452
Neuromuscular blocking agents, n (%)	1,483 (80)	37 (76)	1,446 (80)	0.393
Succinylcholine	1,088 (59)	26 (53)	1,062 (59)	0.462
Rocuronium	168 (9)	3 (6)	163 (9)	0.618
Others	227 (12)	8 (16)	221 (12)	0.398
Mallampati score III or IV, obstructive sleep apnea syndrome, reduced mobility of cervical spine, limited mouth opening, coma, severe hypoxia, nonanesthesiologist as operator score ≥ 3, n (%)	183/1,108 (17)	10/28 (35)	173/1,080 (16)	0.006
Noninvasive ventilation, n (%)	732 (40)	29 (59)	703 (39)	0.005

(*Continued*)

TABLE 1. (*Continued*). Patient Baseline, Provider, and Practice Characteristics

Characteristics	Overall (n = 1,847)	Intubation-Related Cardiac Arrest (n = 49)	No Intubation-Related Cardiac Arrest (n = 1,798)	p
Emergency characteristic of intubation, n (%)				0.006
Real emergency	730/1,773 (40)	30/48 (63)	700/1,725 (40)	
Relative emergency	870/1,773 (48)	18/48 (37)	852/1,725 (49)	
Deferred emergency	173/1,773 (10)	0/48 (0)	173/1,725 (10)	
Length between admission and intubation (d), median (25–75% IQR)	1 (0–5)	0 (0–2)	1 (0–5)	0.055
Preoxygenation, n (%)	1,781 (96)	43 (88)	1,738 (98)	0.0009

BMI = body mass index, IQR = interquartile range, SBP = systolic blood pressure, Spo_2 = peripheral capillary O_2 saturation.
The emergency characteristic of intubation was categorized as follows: real emergency, intubation required without any delay; relative emergency, intubation required within 1 hr; deferred emergency, intubation required in > 1 hr.

score, obstructive apnea syndrome, low thyromental distance, neck circumference, no preoxygenation, and need to release Sellick maneuver for intubation were significantly associated with cardiac arrests. Succinylcholine use was not associated with increased intubation-related cardiac arrest (26/1,088 [2.4%]) compared with rocuronium use (3/168 [1.8%]; $p = 0.79$), other neuromuscular blocker use (8/227 [3.5%]; $p = 0.36$), or absence of neuromuscular blocker use (12/364 [3.3%]; $p = 0.35$).

By multivariate analysis, arterial hypotension (SBP < 90 mm Hg) prior to intubation (odds ratio [OR] = 3.406 [1.797–6.454]; $p = 0.0002$), hypoxemia prior to intubation (OR = 3.991 [2.101–7.583]; $p < 0.0001$), absence of preoxygenation (OR = 3.584 [1.287–9.985]; $p = 0.0146$), overweight/obesity (BMI > 25 kg/m^2; OR = 2.005 [1.017–3.951]; $p = 0.0445$), and age more than 75 years old (OR = 2.251 [1.080–4.678]; $p = 0.0297$) were the five identified independent risk factors for cardiac arrest (**Supplemental Fig. 1*A***, Supplemental Digital Content 1, http://links.lww.com/CCM/D120). The p value of the goodness of fit, assessed by the Hosmer and Lemeshow test, was 0.49, showing acceptable adequacy with data. Area under the ROC curve was 0.79 (0.72–0.87). After internal validation by bootstrap, the area under the ROC curve was 0.79 (0.73–0.86). After sensitivity analysis, main independent risk factors significantly associated with cardiac arrests were the same in the second and the third models (**Supplemental Fig. 1, *B* and *C***, Supplemental Digital Content 1, http://links.lww.com/CCM/D120) as in the main final model (Supplemental Fig. 1*A*, Supplemental Digital Content 1, http://links.lww.com/

TABLE 2. Outcomes According to Intubation-Related Cardiac Arrest

Characteristics	Overall (n = 1,847)	Intubation-Related Cardiac Arrest (n = 49)	No Intubation-Related Cardiac Arrest (n = 1,798)	p
Severe complications during intubation procedure, n (%)	329 (18)	49 (100)	280 (16)	< 0.001
Severe hypoxemia	415 (22)	26 (53)	389 (22)	< 0.001
Severe collapse	536 (29)	49 (100)	487 (27)	0.002
Death	14 (0.7)	14 (29)	0 (0)	< 0.001
Moderate complications during intubation procedure, n (%)	346 (19)	24 (49)	322 (18)	< 0.001
Cardiac arrhythmia	58 (3)	15 (31)	43 (2)	< 0.001
Inhalation	39 (2)	2 (4)	37 (2)	0.331
Esophageal intubation	86 (5)	4 (8)	82 (5)	0.232
Dental injury	15 (0.8)	0 (0)	15 (0.8)	0.522
Difficult intubation	200 (11)	7 (14)	193 (11)	0.430
Agitation	28 (2)	0 (0)	28 (2)	0.378
Others	34 (2)	2 (4)	32 (2)	0.227
Length of ICU stay, median (25–75% IQR)	15 (7–30)	2 (1–10)	16 (7–30)	0.001
Mortality 28 d, n (%)	576 (31)	36 (73)	541 (30)	< 0.001

IQR = interquartile range.

CCM/D120). All but one (overweight or obesity) of the same risk factors as in the main analysis were encountered in the fourth model (**Supplemental Fig. 1*D***, Supplemental Digital Content 1, http://links.lww.com/CCM/D120). OR of intubation-related cardiac arrest according to the number of risk factors are presented in **Supplemental Figure 1*E*** (Supplemental Digital Content 1, http://links.lww.com/CCM/D120).

Outcomes

Severe and moderate complications associated with cardiac arrest are described in **Table 2**. Patients who did not experience intubation-related cardiac arrest had a significantly lower mortality rate at day 28 (30.1%, 541/1,798) than patients who had cardiac arrest (73.5%, 36/49; $p < 0.0001$) (Fig. 1), including cardiac arrest with ROSC (62.8%, 22/35; $p < 0.0001$) (Fig. 1). Kaplan-Meier curves of 28-day mortality according to intubation-related cardiac arrest are presented in **Figure 2** (log-rank test $p < 0.0001$; HR = 4.3 [95% CI, 3.1–6.2]). Twenty-one cardiac arrest patients (45%) died within 48 hours, and 33 cardiac arrest patients (70%) died within 28 days. Intubation-related cardiac arrest was an independent risk factor for day 28 mortality (HR = 3.9 [95% CI, 2.4–6.3]; $p < 0.0001$), after adjustment for age, SAPS II, and shock state as reason for admission (**Supplemental Table 3,** Supplemental Digital Content 1, http://links.lww.com/CCM/D120).

Return of Spontaneous Circulation

Patients failed to attain a ROSC following 14 of these 49 intubation-related cardiac arrests (28.6% of cardiac arrests). Patient, provider, and practice characteristics were similar between the patients with and without ROSC, except for diabetes, Mallampati III/IV, absence of nasogastric tube, and arterial hypotension (SBP < 90 mm Hg), which were significantly more frequent in the group without ROSC (**Supplemental Tables 4** and **5**, Supplemental Digital Content 1, http://links.lww.com/CCM/D120). Outcomes of patients with and without ROSC are presented in **Supplemental Table 6** (Supplemental Digital Content 1, http://links.lww.com/CCM/D120).

DISCUSSION

Intubation-related cardiac arrest was recorded in 49 of 1,847 ICU intubation procedures (2.7%). It was associated with high immediate and 28-day mortality rates (28.5% and 71.4%, respectively) (Figs. 1 and 2) and was determined to be an independent risk factor for day 28 mortality (HR = 3.9 [2.4–6.3]; $p < 0.0001$) (Supplemental Table 3, Supplemental Digital Content 1, http://links.lww.com/CCM/D120). To predict intubation-related cardiac arrest, five independent risk factors were identified, with three potentially actionable high-risk factors (hypoxemia prior to intubation, hemodynamic failure prior to intubation, absence of preoxygenation) that may respond to preventive approaches. Patient characteristics were also identified to be associated with cardiac arrest: BMI greater than 25 kg/m^2 (being overweight or obese) and age more than 75 years old were risk factors (Supplemental Fig. 1*A*, Supplemental Digital Content 1, http://links.lww.com/CCM/D120). The final model was consistent after sensitivity analysis (Supplemental Fig. 1 *B–D*, Supplemental Digital Content 1, http://links.lww.com/CCM/D120) and confirmed after internal validation by bootstrap analysis.

We chose to specifically focus this study on the "cardiac arrest" outcome complication. Cardiac arrest is the major life-threatening intubation-related complication and is challenging to prevent. In the present study, cardiac arrest prevalence during intubation was not low (2.7%), especially when compared with cardiac arrest prevalence during intubation for elective surgery (0.019%) (18). Intubation-related cardiac arrest is therefore more than 100 times more frequent in an ICU setting than in an operative room setting. Considering that 12% of patients admitted to ICU will undergo an intubation procedure (2), and that there are an average of 10 ICU beds for 100,000 inhabitants in the more developed nations (19, 20), more than 25,000 intubation-related cardiac arrests are likely to occur each year worldwide.

Intubation-related cardiac arrest was a major predictive factor of mortality in the ICU

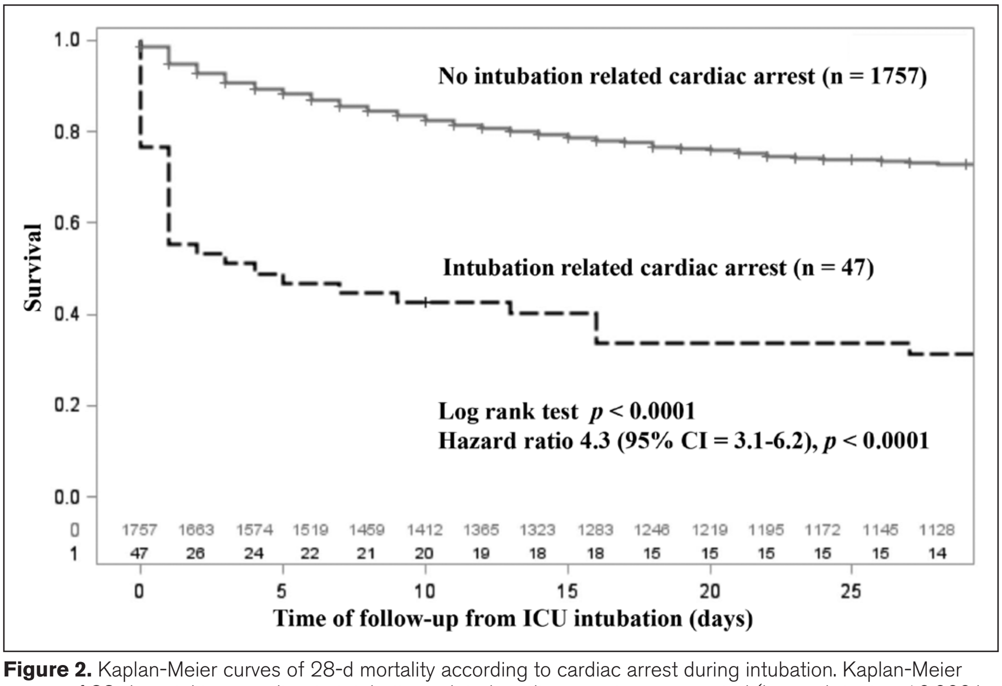

Figure 2. Kaplan-Meier curves of 28-d mortality according to cardiac arrest during intubation. Kaplan-Meier curves of 28-d mortality according to intubation-related cardiac arrest are presented (log-rank test $p < 0.0001$, hazard ratio = 4.3 [95% CI], 3.1–6.2). The Kaplan-Meier curves were built on 1,804 patients. For two patients in the group with intubation-related cardiac arrest and 41 patients in the group without intubation-related cardiac arrest, the status of mortality at day 28 was available but not the time of follow-up.

patients; 28-day mortality was more than three-fold higher when a cardiac arrest occurred during an intubation procedure, after adjustment for potential confounding variables (HR = 3.9 [95% CI, 2.4–6.3]; $p < 0.0001$). Reducing prevalence of intubation-related cardiac arrest is crucial in this context. This study is the first adequately powered to assess risk factors for intubation-related cardiac arrest. Using the five studies, we performed for ICU intubation-related complications, all with similar data collection and methodology, 1,847 intubation procedures were included. The risk factors found for each intubation-related complication, including those identified in the present study for intubation-related cardiac arrest, are summarized in **Supplemental Table 7** (Supplemental Digital Content 1, http://links.lww.com/CCM/D120). It is worthy to note that severe hypoxemia was the main common risk factor for difficult intubation, severe collapse, cardiac arrest, and overall complications.

Identifying patients who are at high risk for cardiac arrest during intubation has several implications in clinical practice. These results highlight interventions that may reduce the likelihood of intubation-related cardiac arrest and therefore 28-day mortality. These interventions potentially include 1) optimizing preoxygenation using NIV and providing oxygen with high-flow nasal cannula oxygen (HFNC) throughout intubation procedure attempts (i.e., apneic oxygenation) to minimize hypoxemia (21, 22), 2) aggressive hemodynamic support before and during intubation procedures (8), and 3) special planning, including application of a standardized protocol for difficult intubation (5). However, intubation-related cardiac arrests were more frequent during real emergency or relative emergency intubations, and time might be too limited to modify preoxygenation, hemodynamics, or intubation devices in case of extreme emergency. In these emergent situations, the risk factors for cardiac arrest may not be modifiable. However, these modifiable risk factors were independently associated with intubation-related cardiac arrest after adjusting for the emergency degree of intubation (Supplemental Fig. 1*D*, Supplemental Digital Content 1, http://links.lww.com/CCM/D120).

Our study has several limitations. First, the possibility of reporting bias and inaccuracy cannot be eliminated in this prospective multicenter observational study. However, the data were collected precisely in an attempt to minimize self-reporting bias and to improve data accuracy. Second, because this is a cohort study, we were not able to eliminate the effect of unmeasured confounders when each factor was evaluated for its association with cardiac arrest. In particular, effect of delayed intubation in patients under NIV (23) or HFNC (24–26) was not assessed and could be a major risk factor for cardiac arrest during intubation procedure. Third, some data were missing in the oldest datasets and could not be found retrospectively. Finally, the five databases were not designed to specifically assess cardiac arrest outcomes and cannot give reliable data for event chronology. However, the baseline patient, provider, and procedure characteristics as the main outcomes were prospectively collected with the same methodology, which limits the potential biases.

CONCLUSIONS

Intubation-related cardiac arrest occurred in one of 40 cases of ICU intubation procedures. Main risk factors for intubation-related cardiac arrest were overweight or obesity, age more than 75 years old, low SBP prior to intubation, hypoxemia prior to intubation, and absence of preoxygenation before intubation procedure. Interventions before and during intubation procedures to improve hemodynamic status and minimize preintubation hypoxemia may prevent intubation-related cardiac arrest and thereby decrease 28-day mortality of ICU patients placed under invasive mechanical ventilation.

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