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Original Article

Prospective multi-center evaluation of the incidence of unplanned extubation and its outcomes in French intensive care units. The Safe-ICU study



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ABSTRACT

Background: We aimed to determine the epidemiology and outcomes of unplanned extubation (UE), both accidental and self-extubation, in ICU.

Methods: A multicentre prospective cohort study was conducted in 47 French ICUs. The number of mechanical ventilation (MV) days, and planned and unplanned extubation were recorded in each center over a minimum period of three consecutive months to evaluate UE incidence. Patient characteristics, UE environmental factors, and outcomes were compared based on the UE mechanism (accidental or self-extubation). Self-extubation outcomes were compared with planned extubation using a propensity-matched population. Finally, risk factors for extubation failure (re-intubation before day 7) were determined following self-extubation.

Results: During the 12-month inclusion period, we found a pooled UE incidence of 1.0 per 100 MV days. UE accounted for 9% of all endotracheal removals. Of the 605 UE, 88% were self-extubation and 12% were accidental-extubations. The latter had a worse prognosis than self-extubation (34% vs. 8% ICU-mortality,

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$p < 0.001$). Self-extubation did not increase mortality compared with planned extubation (8% vs. 11%, $p = 0.075$). Regardless of the type of extubation, planned or unplanned, extubation failure was independently associated with a poor outcome. Cancer, higher respiratory rate, lower PaO₂/FiO₂ at the time of extubation, weaning process not-ongoing, and immediate post-extubation respiratory failure were independent predictors of failed self-extubation.

Conclusion: Unplanned extubation, mostly represented by self-extubation, is common in ICU and accounts for 9% of all endotracheal extubations. While accidental extubations are a serious and infrequent adverse event, self-extubation does not increase mortality compared to planned extubation. © 2024 The Author(s). Published by Elsevier Masson SAS on behalf of Société française d'anesthésie et de réanimation (Sfar). This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Unplanned extubation (UE) is common [1] among mechanically ventilated critically ill patients. UE incidence, better described as the number of events per 100 days of mechanical ventilation (MV), varies between 0.1 and 3.6 for 100 days of MV [2]. UE includes self-extubation (removal of an endotracheal tube by the patient, also called deliberate extubation), which is largely prevalent [3], and accidental extubation (staff-related during nursing or a medical care procedure).

UE is described as a life-threatening complication with immediate and long-term consequences [2]. While the prevention of accidental extubation depends on compliance with already defined good practices [4] (endotracheal tube securement and careful handling), the prevention of self-extubation is at the crossroads of several clinically challenging issues, such as the timing of MV weaning, patient tolerance to an invasive device (related to pain, dyspnoea, or impediment of communication), assessment and treatment of delirium, and patient comfort policy [5]. Inadequate sedation has been reported to be the first risk factor for self-extubation; however, a spontaneous awakening and breathing trial is now recommended in ABCDEF bundle guidelines [6]. The use of physical restraint (common among critically ill mechanically ventilated patients in many countries including France [7]) to prevent self-removal of invasive devices has been reported both as a protective and a risk factor for UE [2].

Studies evaluating outcomes (mortality, intensive care unit length of stay), often with a retrospective design or small prospective cohorts, have reported conflicting results [8–12]. Lower mortality rate was observed in non-re-intubated UE patients [8–12] however, re-intubation rates ranged from 1.8% to 88% in previous studies [2]. The lack of distinction between different UE mechanisms could explain some discrepancies, as accidental extubation patients have poorer outcomes than self-extubation patients [10].

We therefore conducted a multicentre prospective cohort study evaluating UE incidence, characteristics, and outcomes according to the mechanism of UE. In addition, we assessed the hypothesis that failed self-extubation patients (re-intubation at day 7) have worse outcomes compared to successful self-extubation patients and examined possible risk factors for failed self-extubation.

2. Methods

2.1. Study design

This was an observational epidemiological study among French intensive care units (ICUs). Participation was voluntary, enrolled ICUs had responded to a call for participants by the French Society of Anaesthesia and Critical Care (SFAR, Société Française d'Anesthésie-Réanimation). Each ICUs had one representative. This study was approved by the Research Ethics Committee of the French

Society of Anesthesiology and Critical Care Medicine (CERAR), registered as IRB number 00010254-2020-235. Informed consent was waived because of the non-interventional study design. The reporting of this study complies with the STROBE statement (*supplementary file*).

2.2. Participants

The study was conducted for a period of one year split into two phases (Fig. 1). During the first phase, all planned and unplanned extubation were assessed, for a period of three months. During the second phase, only consecutive ICU patients who underwent an UE were included to decrease the workload of this ungranted study. An epidemiological analysis was conducted for one year to measure planned and unplanned extubation incidence (all consecutive events).

UE was defined as the removal of an oral or nasal endotracheal tube (ETT) without the possibility of reinserting without a new laryngoscopy [8]. ETT removal by the patient was labeled self-extubation, and extubation due to accidental manipulation by an ICU staff member (during nursing for example) was accidental extubation. Failure of self-extubation (failed self-extubation) was defined as re-intubation on day 7 after extubation. For patient's outcome analysis, we only included the first episode of planned or unplanned extubation.

We excluded patients refusing the use of their data and patients under legal protection; we also excluded data when the assessment of re-intubation on day 7 was missing.

2.3. Data collection

Patient data were anonymously collected on an electronic case report file (<https://redcap.sfar.org/>) powered by the SFAR research network. The list of data has been published in the online supplement.

2.4. Outcome measures

The main outcome measure was the incidence of UE. Secondary outcomes were planned and unplanned extubation failure, ICU mortality (D28 mortality), ICU length of stay, and duration of MV.

2.5. Statistical analysis

The incidence of UE was calculated as the number of UEs per 100 days of MV = (number of UEs × 100)/number of MV days (over a minimum three-month period).

Descriptive analyses of the study population were performed. We summarized quantitative values using medians and inter-quartile ranges (IQR) and made comparisons using an independent samples *t*-test for normally distributed variables and the Mann-Whitney *U* test for those that were not. Qualitative values were summarised using numbers and percentages, and comparisons

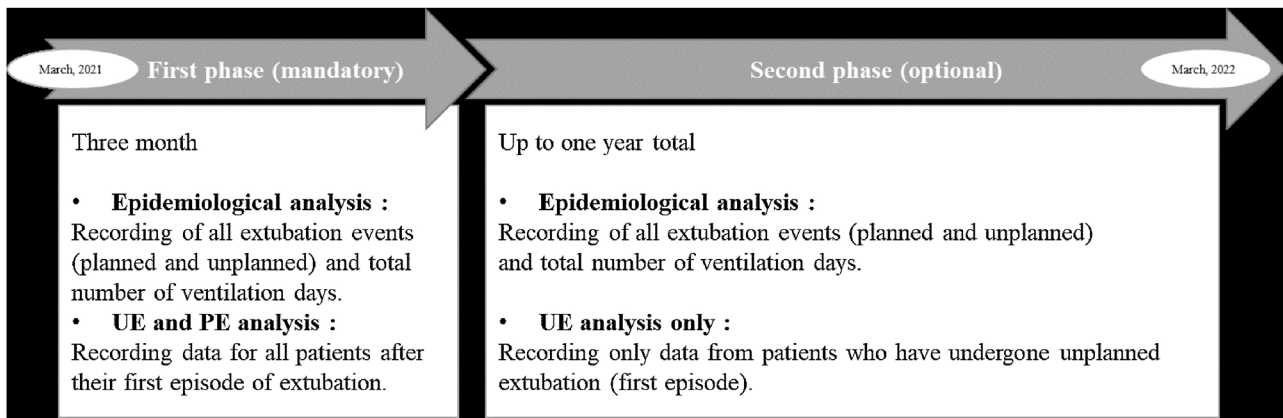


Fig. 1. Description of the two study phases.

were made using Pearson's Chi-2 test or Fisher's exact test, as appropriate. Normality was checked graphically by examining histograms and quantile-quantile diagrams as well as by the Kolmogorov-Smirnov test.

The probability of spontaneous breathing without re-intubation (time before re-intubation) after self-extubation, accidental extubation, or planned extubation was compared using a Log-rank test. Spontaneous breathing without re-intubation was defined as the patient maintaining adequate ventilation and oxygenation without the need for re-intubation or non-invasive mechanical ventilation, however, this does not exclude the use of prophylactic non-invasive respiratory support post-extubation.

A Factorial Analysis of Mixed Data was realized to visually compare individual data for the different groups: planned extubation, self-extubation, and accidental extubation. Age, Sex, body mass index, COVID status, SAPS-2, Number of ventilatory days before extubation (planned or unplanned), PaO₂ over FiO₂ ratio at the time of extubation, and delirium status were included in the analysis.

Outcomes of self-extubation were compared to planned extubation using a propensity score matching (nearest neighbor matching). To sum up, the propensity score of self-extubation was estimated using logistic regression including variables significantly different between patients planned or self-extubated (threshold of $p < 0.10$). The variables included were: age, gender, body mass index, Sars-Cov2 infection status, SAPS-2, length of ICU stay prior to extubation, PaO₂/FiO₂ ratio prior to extubation, and delirium status. A one-to-one matching was then realized. To explain mortality, a multivariable analysis with extubation type (planned or self-extubation) and clinically relevant and not collinear variables used in the previous logistic regression was performed. To determine any unmeasured confounding variable, the E value for self-extubation – assessing the minimum strength of association that an unmeasured confounder would need to have to rule out the association between self-extubation and mortality – was calculated using the previously reported method [13].

To determine the independent risk factors for self-extubation failure, a multivariable analysis was performed by logistic regression including clinically relevant and not collinear variables, whose significance threshold was less than 0.20 in univariate analysis. Variables with more than 20% missing data were not entered into the model. If a variable had less than 20% missing data, a multiple imputation by chain equations (MICE) was performed. With a multivariable model with 10–15 parameters, we needed at least 150 self-extubation failures. Based on a self-extubation rate of 85% of all UEs, and an estimated failure rate of 30%–40%, we

needed to include at least 500 patients [2]. For practical reasons, the inclusion period was limited to 12 months.

The assumptions of the logistic regression models was tested and reported in the supplementary materials.

All data were analyzed using R software Version 3.4 (R Foundation for Statistical Computing, Vienna, Austria; <https://www.R-project.org/>) and GraphPad Prism (version 8.0.0 for Windows, GraphPad Software, San Diego, California, USA, www.graphpad.com). All statistical tests were 2-sided, and $p < 0.05$ was considered to indicate statistical significance.

3. Results

Fig. 2 provides a flowchart of the centres, patients, and UEs.

3.1. Primary outcome

Data were collected from 47 ICUs throughout France (Supplementary Fig. 1). The median bed capacity was 15 [IQR 12–23]. The nurse/patient ratio was greater than 1:2 in 68% of all centers. Usage of MV weaning and pain/sedation protocols was 43% and 79%, respectively (Supplementary Table 1). Out of the 47 ICUs participating in the study, 45 completed a full prospective period of monitoring UEs. Over 41,574 MV-days, there were 4453 planned extubations (PE) and 428 UEs, equalling a pooled UE incidence of 1.0 per 100 MV-days and a pooled UE:PE ratio of 0.1. UEs accounted for 9% of all endotracheal removals. The median UE incidence among participating ICUs was 0.9 [IQR 0.5; 1.4] per 100 MV-days, with a range of 0–4.3 per 100 MV-days (Supplementary Fig. 2). Among the ICUs' characteristics, only systematic CAM-ICU evaluation ($p = 0.03$) and planned extubation incidence ($r = 0.3$, $p = 0.04$) were significantly associated with UE incidence (Supplementary Table 1).

3.2. Secondary outcomes

3.2.1. Unplanned extubation characteristics

During the 12-month inclusion period, 605 patients experienced at least one episode of UE, 535 (88%) of which were self-extubations and 70 (12%) were accidental extubations. Of the 605 patients, 463 (77%) were men, the median age was 57 years [IQR 43–67], 357 (58%) were admitted to ICU for a medical condition, and 109 (18%) were admitted due to SARS-CoV2 infection. Median SAPS-2 was 44 [IQR 29–57] (Table 1). The median ICU LOS at the time of UE was 4 days [IQR 4–9]. Accidental extubation patients were significantly older, had a higher body

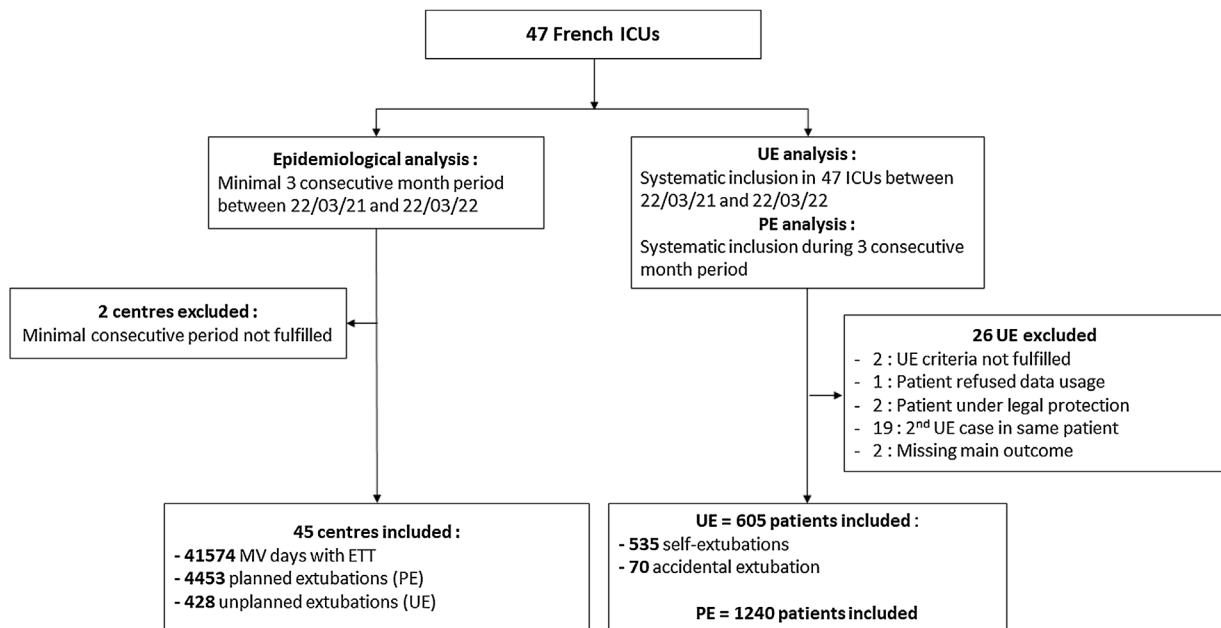


Fig. 2. Study flow chart. MV, mechanical ventilation? ETT, endotracheal tube. PE, planned extubation. UE, unplanned extubation, ICU intensive care unit.

mass index, were more often admitted for medical disorders including SARS-CoV-2 infection, and had longer ICU LOS at the time of UE than did self-extubation patients. Concerning the last clinical evaluation before UE, accidental extubation patients had lower PaO₂/FiO₂ and lower RASS; they were also more frequently under controlled ventilation and continuous intravenous (IV) sedation. Self-extubation patients had more frequent physical restraints, and 56 (12%) had delirium at the time of UE (Table 1). No family members or staff were present in the room at the time of the self-extubation in 87% of cases (466/535).

3.2.2. Unplanned extubation risk factors

Demographics and clinical characteristics of patients with self or accidental extubations were compared to planned extubation patients (Supplementary Table 2). Factor analysis of the mixed data (Supplementary Fig. 3) shows an overlap between patients with planned extubation and those with self-extubation. Only higher duration of mechanical ventilation, lower PaO₂/FiO₂ were independently associated with accidental extubation compared with planned extubation (Supplementary Fig. 4). UE time was most frequent during day shift, especially at 8 AM for accidental events (number of events by time of day displayed in Supplementary Fig. 5). Discomfort was the most common reason for self-extubation reported both by patients able to communicate (76%) and physicians in the opposite case (52%), followed by involuntary movement (reported by patients, 18%) or restlessness (reported by physicians, 42%).

Accidental extubation patients developed significantly more immediate complications (cardiorespiratory arrest, respiratory and hemodynamic severe complications). Seven days after UE, 186 self-extubation patients (35%), versus 58 accidental extubation patients (83%), were re-intubated ($p < 0.001$) (Fig. 3). Time to reintubation was significantly shorter in patients with accidental extubation (4 min [IQR 1–14] vs. 102 min [IQR 14–1122], $p < 0.001$) (Table 2). They have a higher duration of MV, ICU LOS, and D28 mortality compared to self-extubation patients (Table 2).

3.2.3. Unplanned extubation outcomes

Self-extubation complications and outcomes are summarized in Supplementary Table 4. Compared with planned extubation, self-extubated patients' baseline characteristics were different for age, sex, BMI, SAPS-2, ICU LOS, PaO₂/FiO₂, and presence of delirium (Supplementary Table 2 before propensity matching). After a propensity score adjustment (Supplementary Fig. 6), all baseline characteristics were similar (Supplementary Tables 4 & 5), and self-extubated patients had a higher extubation failure rate (35% vs. 15%, $p < 0.001$), longer duration of mechanical ventilation (6 vs. 4 days, $p < 0.001$), but similar mortality (8% vs. 11%, $p = 0.075$) compared with planned-extubated patients. A multivariable analysis found out that age, SAPS-2, and extubation failure were independently associated with mortality. On the other side, higher PaO₂/FiO₂ and self-extubation were associated with a decrease in mortality. The E value for self-extubation was 3.2 (Fig. 4).

Variables significantly different in univariable analysis between patients with and without extubation failure following self-extubation are reported in Supplementary Table 6. In the multivariable analysis, cancer, respiratory rate, PaO₂/FiO₂, not being in the process of weaning, and the presence of an immediate respiratory complication were independently associated with extubation failure (Fig. 5).

4. Discussion

The main results of this large prospective multicentre study show that UE is frequent, around 9% of all extubations in ICU. Accidental extubation has a poorer prognostic than self-extubation. Compared with planned extubation, self-extubation is associated with a higher risk of extubation failure but is not associated with an increase in mortality. Self-extubation is mainly explained by patient discomfort far more than delirium or agitation.

UE incidence in our study is consistent with the results of a recent meta-analysis that found a combined incidence of 1.06 UEs per 100 MV days across 16 studies [14]. Moreover, Da Silva et al. [2]

Table 1
Characteristics of the study patients and unplanned extubation events.

| | Total Population (n = 605) | Self-extubation (n = 535) | Accidental extubation (n = 70) | Missing data | P |
|---|----------------------------|---------------------------|--------------------------------|--------------|-------|
| Demographic and clinical | | | | | |
| Age, years | 57 [43–67] | 56 [43–66] | 61 [48–69] | 0 | .04 |
| Sexe, man | 463 (77%) | 407 (76%) | 56 (80%) | 0 | .46 |
| BMI, kg/m ² | 26 [23–30] | 26 [23–30] | 28 [24–33] | 16 | <.01 |
| Comorbidities | | | | | |
| Smoking | 174 (29%) | 156 (29%) | 18 (26%) | 0 | .55 |
| Alcohol addiction | 128 (21%) | 117 (22%) | 11 (16%) | 0 | .24 |
| Other substance addiction | 42 (7%) | 38 (7%) | 4 (6%) | 0 | .81 |
| Underlying heart disease | 111 (18%) | 97 (18%) | 14 (20%) | 0 | .69 |
| Underlying lung disease | 90 (15%) | 79 (15%) | 11 (16%) | 0 | .83 |
| Liver cirrhosis | 33 (6%) | 29 (5%) | 4 (6%) | 0 | .79 |
| End stage renal disease | 17 (3%) | 16 (3%) | 1 (1%) | 0 | .71 |
| Cancer | 76 (13%) | 65 (12%) | 11 (16%) | 0 | .40 |
| Immunosuppression | 59 (10%) | 52 (10%) | 7 (10%) | 0 | .94 |
| Admission type | | | | | |
| Medical | 357 (59%) | 305 (57%) | 52 (74%) | 0 | <.01 |
| Surgical | 248 (41%) | 230 (43%) | 18 (26%) | 0 | |
| SARS-CoV-2 infection (admission) | 109 (18%) | 88 (16%) | 21 (30%) | 0 | <.01 |
| SAPS-2 (admission) | 44 [29–57] | 44 [29–57] | 44 [30–56] | 30 | .37 |
| ICU-LOS before UE, days | 4 [1–9] | 4 [1–9] | 8 [3–14] | 0 | <.01 |
| Most recent data before UE | | | | | |
| Respiratory rate, min ⁻¹ | 22 [18–26] | 21 [18–26] | 22 [19–30] | 7 | .061 |
| PaO ₂ /FiO ₂ , mmHg | 242 [185–320] | 246 [187–322] | 210 [162–276] | 57 | .04 |
| SpO ₂ , % | 97 [95–99] | 97 [95–99] | 97 [95–98] | 7 | .27 |
| Ventilation | | | | | |
| Controlled | 153 (25%) | 115 (21%) | 38 (54%) | 0 | <.001 |
| Assisted | 452 (75%) | 420 (79%) | 32 (46%) | 0 | – |
| Weaning started ^a | | | | | |
| RASS | 198 (33%) | 182 (34%) | 16 (23%) | 0 | .06 |
| BPS | 0 [–2 to 0] | 0 [–2 to 0] | –3 [–5 to 0] | 42 | <.001 |
| Continuous sedation | | | | | |
| Any | 3 [3–4] | 3 [3–4] | 3 [3–3] | 73 | .24 |
| Propofol/midazolam | 277 (46%) | 259 (48%) | 18 (26%) | 0 | <.001 |
| Halogen | 200 (33%) | 157 (29%) | 43 (61%) | 0 | <.001 |
| Dexmedetomidine | 3 (1%) | 3 (1%) | 0 (0%) | 0 | 1.00 |
| Opioids | 97 (16%) | 93 (17%) | 4 (6%) | 0 | .01 |
| Delirium | 195 (32%) | 154 (29%) | 41 (59%) | 0 | <.001 |
| Physical restraints | 61 (12%) | 57 (13%) | 4 (6%) | 91 | .14 |
| UE environmental factors | | | | | |
| Endotracheal tube securement | | | | | |
| Twill tape | 440 (72%) | 407 (76%) | 33 (47%) | 0 | <.001 |
| Adhesive tape | 218 (36%) | 199 (37%) | 19 (27%) | 0 | .16 |
| Commercial tube holder | 316 (52%) | 277 (52%) | 39 (56%) | 0 | – |
| Patient position at time of UE | 73 (12%) | 61 (11%) | 12 (17%) | 0 | – |
| Lying | 602 (99%) | 533 (99%) | 69 (99%) | 0 | .46 |
| Sitting | 5 (1%) | 4 (1%) | 1 (1%) | 0 | – |
| UE time | | | | | |
| Day time (7 am–7 pm) | 5 (1%) | 4 (1%) | 1 (1%) | 0 | .29 |
| Night time (7 pm–7 am) | 362 (60%) | 316 (59%) | 46 (66%) | 0 | – |
| Occurring during critical period ^b | 243 (40%) | 219 (41%) | 24 (34%) | 0 | – |
| | 133 (22%) | 121 (23%) | 12 (17%) | 1 | .30 |

BMI, body mass index; SAPS-2, Simplified Acute Physiology Score-2; ICU-LOS, ICU length of stay; UE, unplanned extubation.

Data expressed in number (%) or median [interquartile range Q1–Q3].

^a Spontaneous breathing trial in the last 24 h.

^b Critical period: changeover timing or lunch break of the ICU staff.

found a similar incidence in their 2012 meta-analysis demonstrating a stable UE rate over time. The incidence of UE varies considerably from one center to another (ranging from 0 to 4.3 UEs per 100 MV days in our study), which explains the divergent results obtained in previous studies, most of which were monocentric. In our study, only systematic CAM-ICU evaluation and high incidence of planned extubation were associated with an increased risk of UE. To our knowledge, this is the first study to assess the incidence of UE in multiple ICUs with various practices (according to different elements of the ABCDEF bundle), ICUs size, and number of caregivers. Early mobilization is not associated with an increased risk of UE, in our cohort, less than 1% of UE occurred when patients were in a chair [15,16]. We can speculate that in ICU with an aggressive ICU liberation policy and more ABCDEF elements, sedation targets are lighter, resulting in more planned extubations, but also more self-extubations. Self-extubation may

be the price to pay for achieving light sedation, a key objective in intensive care units [6]. The proportion of self-extubations was lower in ICUs with a liberal family engagement policy, only 13% of self-extubations occurred when a family or staff member was present at the patient’s bedside. This should encourage family engagement.

Secondly, we analyzed patient characteristics and outcomes according to the UE mechanism. Accidental extubation was associated with a mortality rate four times higher than self-extubation. The main difference between accidental and self-extubation is the level of sedation (RASS –3 vs. 0). Patients with light sedation have routinely more physical restraints at least in France and south of Europe [7]. The number of patients with a RASS score > +1 was low in our study. The sudden withdrawal of ventilatory support (accidental extubations were more often in volume control mode) in severe patients with intravenous

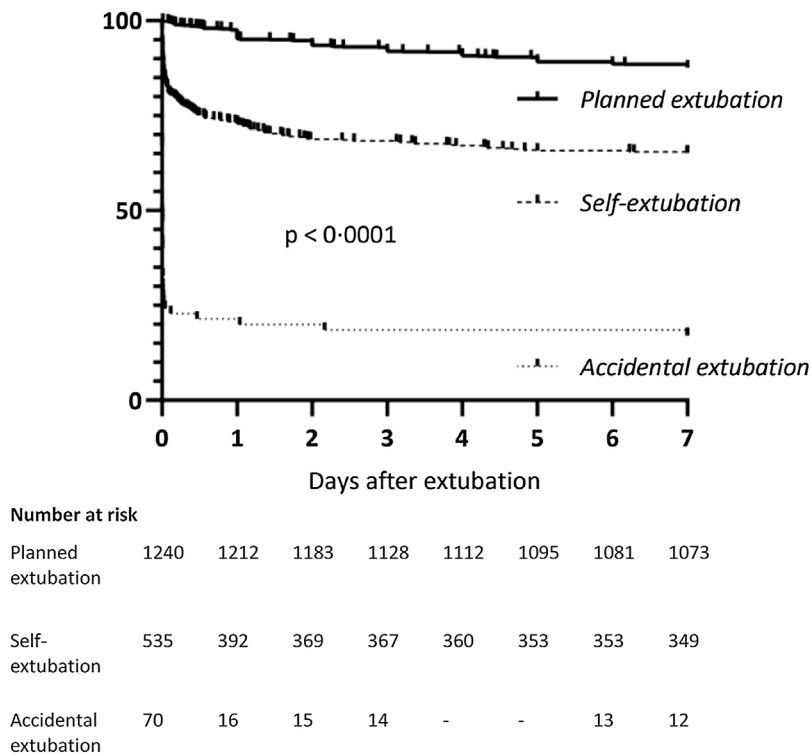


Fig. 3. Kaplan Meier curve for spontaneous breathing without re-intubation: planned, self, or accidental extubation.

Table 2
Immediate complications and outcomes according to the unplanned extubation mechanism.

| | Total population (n = 605) | Self-extubation (n = 535) | Accidental extubation (n = 70) | Missing data | P |
|---|----------------------------|---------------------------|--------------------------------|--------------|-------|
| Immediate complications (1 h post UE) | | | | | |
| Cardio-respiratory arrest | 2 (0%) | 0 (0%) | 2 (3%) | 0 | .01 |
| Severe hemodynamic complication | 22 (4%) | 12 (2%) | 10 (14%) | 1 | <.001 |
| Severe respiratory complication | 205 (34%) | 167 (31%) | 38 (54%) | 0 | <.001 |
| Re-intubation (day 7 post UE) | 244 (40%) | 186 (35%) | 58 (83%) | 0 | <.001 |
| Difficult intubation | 24 (10%) | 18 (10%) | 6 (10%) | 0 | .88 |
| Time to re-intubation, minutes | 31 [5–619] | 102 [14–1122] | 4 [1–14] | 0 | <.001 |
| ICU mortality (day 28 post UE or discharge) | 66 (11%) | 42 (8%) | 24 (34%) | 1 | <.001 |
| Time to death after UE, days | 9 [3–18] | 12 [3–19] | 8 [3–16] | 0 | .97 |
| Length of mechanical ventilation time, days | 7 [2; 17] | 6 [2–15] | 17 [7–27] | 0 | <.001 |
| ICU-LOS, days | 14 [6–27] | 13 [16–24] | 26 [13–36] | 0 | <.001 |

Data expressed in number (%) or median [interquartile range Q1–Q3].
UE, unplanned extubation; ICU-LOS, ICU length of stay.

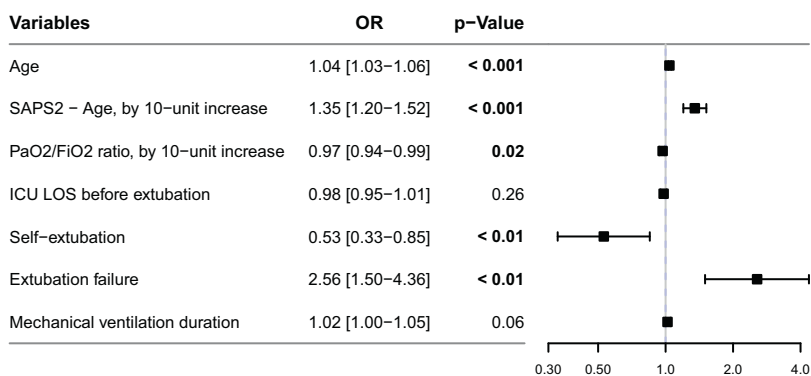


Fig. 4. Multivariable analysis, determinants associated with mortality (planned-extubated patients versus self-extubated patients after propensity score adjustment). SAPS2, simplified acute physiology score 2. ICU LOS, intensive care unit length of stay. PaO₂/FiO₂ at extubation.

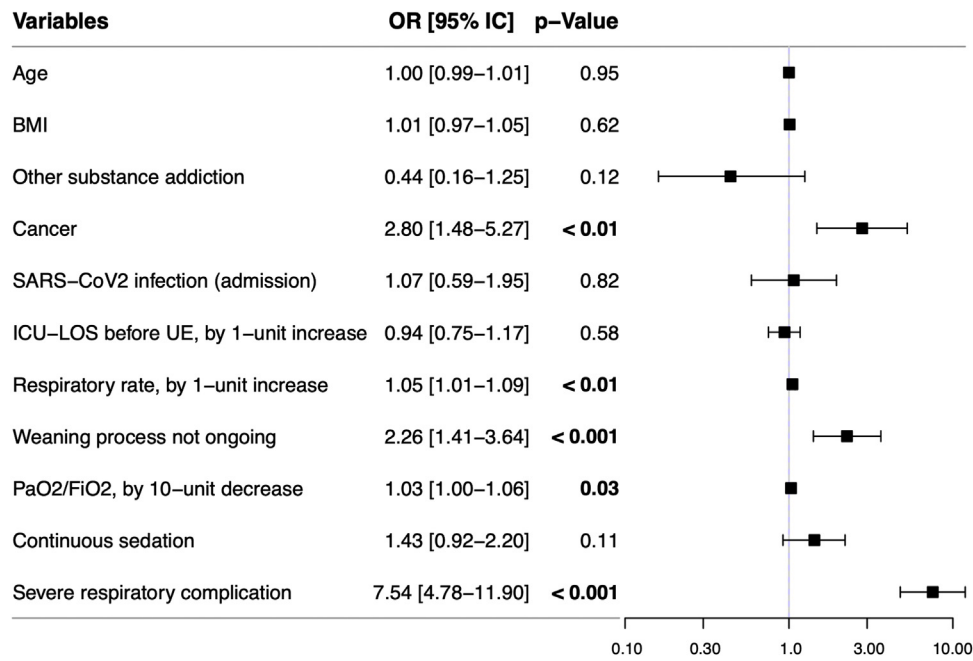


Fig. 5. Multivariable analysis, determinants associated with self-extubation failure. BMI, body mass index. ICU-LOS, intensive care unit length of stay. UE, unplanned extubation. Severe respiratory complication at 1-h post UE (respiratory distress, hypoxemia, hypercapnic acidosis).

therapies (sedation, vasoactive drugs, etc.) could explain a high rate of immediate complications after accidental extubation (2.8% had cardiac arrest and 54% had a severe respiratory complication). Moreover, patients with accidental extubation were more often reintubated (83%), which increases the risk of nosocomial pneumonia and, consequently, the duration of MV (threefold risk) and the length of stay in ICU (twofold risk) compared with self-extubation. De Lassence *et al.* demonstrated that accidental extubation is an independent risk factor for nosocomial pneumoniae, compared with self-extubation and planned extubation [17]. No individual risk factors for accidental extubation were identified except higher duration of mechanical ventilation before extubation and lower PaO₂/FiO₂. The Factorial Analysis of Mixed Data (Supplementary Fig. 3) clearly shows the overlap of demographics and clinical characteristics among patients with planned, self, or accidental extubations. We can therefore assume that accidental extubations seem to be more closely linked to care and caregivers than to patient characteristics. This is consistent with the high incidence of accidental extubations during the 8 a.m. time slot, a period around the shift change when morning rounds and patient assessments are typical. Although this is a hypothesis, future research should focus on care strategies aimed at reducing these dramatic but highly avoidable events.

In comparison to planned extubation, self-extubation is associated with a heightened risk of extubation failure, yet it does not yield an increased mortality rate. Multivariable analysis reveals a paradoxical and surprising protective effect of self-extubation on mortality, likely attributable to non-measured factors such as diminished ICU weakness, elevated vigilance levels, and heightened efficacy in coughing. Indeed, the low E-value of 3.2 - assessing the minimum strength of association that an unmeasured confounder would need to have to rule out the association between self-extubation and mortality - makes the substantial contribution of residual confounding factors more likely.

Cancer patients, higher respiratory rate before self-extubation, weaning process not ongoing, lower PaO₂/FiO₂, and immediate severe respiratory complication were independent predictors for

self-extubation failure. Tachypnoea and the absence of weaning prior to UE have previously been identified as predictors of UE failure [9,15]. A recent meta-analysis of extubation outcomes in critically ill patients [18] found that lower PaO₂/FiO₂ at extubation was a risk factor for extubation failure. Risk factors of extubation failure are not different for planned or self-extubation.

One of the strengths of this study is that it used systematic interviews with patients after self-extubation. Discomfort was the main reason for self-extubation reported by patients able to communicate (76%). In addition, 87% of episodes occurred without staff or relatives in the room, which is known to increase anxiety and discomfort [16]. The assessment and treatment of pain [19], dyspnoea [20], and anxiety [21] in mechanically ventilated patients are clinically challenging issues. The inability to manage these unpleasant physical or psychological symptoms could be the primary reason for self-extubation, as the ETT represents the patient's projected source of discomfort and/or communication barrier. The stable incidence of UE over time [2] (the majority being self-extubation) shows the complexity of self-extubation prevention. In the future, these findings should prompt physicians and researchers to examine the relationship between patient discomfort and self-extubation, with the goal being patient-centered care [5].

There were several limitations to this study. First, the COVID-19 pandemic may have increased UE incidence. Chhina *et al.* [22] reported COVID-19 patients to be at higher risk of UE than non-COVID-19 patients. Moreover, the crisis (increased workload, shortage of equipment, and caregivers) may have had an impact on epidemiology. Nevertheless, COVID-19 was not a risk factor associated with unplanned extubation in the multivariable analysis. Second, we exclusively enrolled patients undergoing planned extubation within the initial three months to streamline study participation. This approach may introduce a selection bias, partially mitigated by propensity score matching (Supplementary Fig. 6). Third, we did not report data on caregiver experience [23,24] and use of standardized surveillance of ETT position [25], both of which demonstrate a potential link to UE in previous studies. Regarding the case analysis, our study was limited to a

national setting with specific practices (France has a high use of physical restraint [7]), thereby limiting external validity. The self-extubation *versus* accidental extubation definitions used in the study could not cover all clinical scenarios and led to classification bias. Although cases were identified prospectively, some data, such as the latest clinical variables before UE, were extracted retrospectively and may not reflect the exact clinical status at the time of UE. Despite the limitations, we strongly believe our findings support a specific definition of accidental extubation or self-extubation in future research that aims to assess/prevent/care for these two distinct events related to mechanical ventilation.

5. Conclusion

UE is a frequent event in ICUs, accounting for 9% of all endotracheal removals. Distinguishing accidental extubation from self-extubation is key to understanding UE. Accidental extubation is rare but is associated with dramatically higher incidence of immediate post-extubation complications and increased mortality compared to self-extubation. Self-extubation is not associated with an increase in mortality compared to planned extubation. Discomfort is the main reported cause of self-extubation. These findings may lead to future quality improvement programs to avoid accidental extubation and reduce self-extubation and its associated morbidity.

Ethical statement

Ethical approval: Research Ethics Committee of the French Society of Anesthesiology and Critical Care Medicine (CERAR), registered as IRB number 00010254-2020-235.

Conflict of interest

All authors declare they have no conflict of interest with this work.

Declarations

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Availability of data and materials: Data is provided within the manuscript or supplementary information files.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.accpm.2024.101411>.

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