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Tracheostomy, Extubation, Reintubation: Airway Management Decisions in Intubated Stroke Patients

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Keywords

Stroke · Tracheostomy · Extubation · Reintubation · Airway management · Clinical decision making

Abstract

Background: Both delayed and premature extubation increase complication rate, the need for tracheostomy (TT), the duration of intensive care unit stay, and mortality. In this study, we therefore investigated factors associated with primary TT and predictors for extubation failure (EF) in a sample of severely affected ventilated stroke patients. ***Methods:*** One hundred eighty five intubated stroke patients were prospectively analyzed in this observational study. Patients not meeting predefined clinical and respiratory extubation criteria received a TT. All other patients were extubated and followed up for the need of reintubation. Characteristics of patients with and without extubation attempt were examined. Additionally, within the group of extubated patients, subgroups of successfully vs. unsuccessfully extubated patients were compared. Clinical factors associated with reintubation, including a previously established semi-quantitative airway score, were determined and predictors of EF were assessed. ***Results:*** Ninety-eight of 185 patients (53%) were primarily extubated; EF rate was 37% (36 patients). Eighty-seven (47%) were tracheostomized without a prior extubation attempt. Primarily tracheostomized patients had more severe strokes, which were more often hemorrhagic, presented with a lower level of consciousness, needed neurosurgical intervention more often, had a higher rate of obesity, and were more frequently intubated because of suspicion of compromised protective reflexes. EF was independently predicted by prior neurosurgical treatment and low airway management scores. No differences were found for the ability to follow simple commands and classical weaning criteria. ***Conclusion:*** Airway management decisions in intubated stroke patients represent a clinical challenge. Classical weaning criteria and parameters reflecting the patient's state of consciousness are not reliably predictive of extubation success. Criteria more closely related to airway safety and secretion handling may provide the most relevant information and should therefore be assessed by specific clinical scoring systems.

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Introduction

Orotracheal intubation and subsequent invasive mechanical ventilation (MV) belong to the most common procedures on any intensive care unit (ICU). Although often necessary and life-saving, MV itself is time-dependently associated with various complications, in particular ventilator-associated pneumonia, and may increase morbidity and mortality [1]. Therefore, modern ICU regimes are aimed to withdraw ventilatory support as early as is safely possible [2]. The first phase in this 2-step process termed respirator weaning or liberation has been extensively investigated. Strategies of both continuous progressive withdrawal of ventilatory support as well as discontinuous methods involving spontaneous breathing trials have been developed, refined, and accepted in mostly non-neurologic ICU patients during the last decades [3, 4]. The second phase of this process, which is more controversial among clinicians, involves determining whether the successfully weaned patient still needs an artificial airway or can be safely extubated [5]. Both delayed and premature extubation increase complication rates, need for tracheostomy (TT), duration of ICU stay, and mortality [6–10], highlighting the prognostic importance of this decision. Interestingly, in spite of considerable research devoted to this topic, the rate of airway management complications after extubation has not improved over the last 20 years [11]. Extubation failure (EF) rates in unselected ICU patients vary between 10 and 20% [12–15]. EF is a necessary occurrence in a properly functioning ICU and a rate of zero is neither desirable nor possible, as it would imply an overly cautious approach to extubation or an excessive TT rate. The ideal false positive rate for extubation likely varies by patient population and clinical experience. Remarkably, there is clear evidence that neurological ICU patients are especially prone to EF, with reintubation rates ranging from 20 to 40% [16]. This large variety of EF rates across studies may indicate that risk factors for EF are related to the specific disease state of the respective patient population. In neurological patients, issues of airway safety due to a disturbance of consciousness or bulbar dysfunction are more prevalent and relevant than the pulmonary pathologies more frequently seen in medical or surgical ICU populations.

Stroke is a leading cause of morbidity and mortality worldwide [17]. Due to the availability of more aggressive and invasive treatment options, such as mechanical thrombectomy and decompressive surgery, the percentage of stroke patients being admitted to the ICU is constantly increasing [18], making stroke the leading diagnosis on neurological ICUs [19–22]. Due to the relevance of respiratory complications in this patient group, optimal airway management is paramount. However, prospective data on factors or predictors associated with the need for TT or EF hardly exist.

In this study, we therefore investigated characteristics differentiating stroke patients with a need to be tracheostomized from those receiving an extubation attempt and predictors for EF in a sample of severely affected ventilated stroke patients.

Methods

Study Design

This was a bi-centric, prospective observational study with predefined endpoints carried out at 2 German academic neurointensive care units.

Patients

Intubated patients aged over 18 years with ischemic or hemorrhagic stroke were eligible for study inclusion. Exclusion criteria were the presence of a do-not-resuscitate order as well as a palliative treatment approach, possibly leading to final extubation. Consecutive patients were recruited in 2011 over a period of 8 months in Muenster, and 3 months in Heidelberg. The nature of the study was approved by the local institutional Ethics Committees. Informed consent was obtained from all subjects' next of kin or legal representative, when the patient's communication was impaired.

Procedures

All management decisions were made at the discretion of the treating physician with a specialization in neurological intensive care medicine, who was not involved in the study conduct. In particular, the procedures TT vs. extubation were indicated by the ward physician. Analgesia and sedation were stopped up to 72 h prior to planned extubation. An attempt to hold sedation and perform a spontaneous breathing trial was made as soon as there were no more circumstances possibly leading to elevated intracranial pressure (ICP). Following local guidelines, extubation was carried out if the following clinical extubation criteria were fulfilled: (i) level of consciousness was at least soporous (Glasgow Coma Scale [GCS] >8), (ii) no signs of elevated ICP (judged clinically or by measurement, ICP <20 mm Hg), (iii) at least attempts of swallowing and coughing, (iv) systolic blood pressure between 90 and 185 mm Hg, (v) heart rate between 60 and 120 bpm, and (vi) body temperature between 36 and 38.5 °C. Additionally, the following respiratory extubation criteria (REC) were considered: (i) spontaneous respiratory minute volume (≤12 L), (ii) PEEP (≤5 mm Hg), (iii) paO2/FiO2 (>200), and (iv) the ratio of respiratory frequency to tidal volume (Rapid Shallow Breathing Index [RSBI] <105).

For a subgroup of patients at one of the study sites (Muenster), a previously established semi-quantitative airway score (sqAS) [23] was assessed 24 h before extubation. The sqAS contains the parameters spontaneous cough, gag, sputum quality, and quantity and has been routinely used at the neuro-ICU in Muenster since

2009. We used the following score graded on a 15-point scale with higher numbers (0–3) indicating worse airway function (online suppl. Table 1, see www.karger.com/doi/10.1159/000471892): spontaneous cough (vigorous: 0, moderate: 1, weak: 2, none: 3), gag (vigorous: 0, moderate: 1, weak: 2, none: 3), sputum quantity (none: 0, one suctioning pass: 1, 2 suctioning passes: 2, more than 2 suctioning passes: 3), suctioning frequency (>3 h: 0, 2–3 h: 1, 1–2 h: 2, <1 h: 3), sputum viscosity (watery: 0, frothy: 1, thick: 2), sputum character (clear: 0, tan/yellow: 1). In comparison to the original publication, the grading of the last 2 criteria, that is, sputum viscosity and sputum character had been shortened from originally 4 to 3 and 2 levels, respectively [23].

EF was defined as reintubation within 72 h after extubation. The reason for reintubation as stated by the treating physician was documented. Patients not meeting clinical extubation criteria received a TT without prior extubation attempt.

Endpoints

The primary endpoints of the study were (i) primary extubation (as opposed to primary TT) and (ii) EF. Only the first extubation/reintubation event of each included patient was taken into account. Secondary endpoints were duration of sedation and ventilation, incidence of pneumonia as diagnosed by the ward physician, need for multiple antibiotics (>2), length of stay (LOS) on the ICU (ICU-LOS), total in-hospital-LOS, and functional outcome at discharge measured by the modified Rankin Scale (mRS).

Statistical Analysis

Statistical analysis was confined to 2 topics. First, groups of patients with and without extubation attempt were compared. Second, within the group of extubated patients, subgroups of successfully and unsuccessfully extubated patients were contrasted against each other. For univariate comparisons, the *t* test (2 groups) or ANOVA (>2 groups) was used for continuous variables, the chi-square or Fisher exact test for categorical variables and the Mann–Whitney U test for ordinal variables. Using binary logistic regression analysis, independent predictors of EF were determined. Data analysis was performed using IBM SPSS statistics version 21.

Results

One hundred eighty-five patients with ischemic (80%) or hemorrhagic (20%) stroke requiring intubation and MV were included. Demographic and clinical characteristics are summarized in Table 1. There were no differences with regards to age, gender, comorbidities, and stroke etiology between the group of patients undergoing extubation and those patients being tracheostomized without prior extubation attempt.

Extubation versus TT

Ninety-eight of 185 patients (53%) were primarily extubated and 87 (47%) were tracheostomized without any previous extubation attempt. Compared to those receiving an extubation attempt, primarily tracheostomized patients had more hemorrhagic strokes, higher National Institute of Health Stroke Scale (NIHSS), and lower GCS scores on admission, and were more often obese (body mass index >30). Recanalizing therapies were more frequently performed in patients later deemed ready for extubation, whereas neurosurgical treatment was more than twice as frequent in patients being primarily tracheostomized. In addition, indications for intubation were unevenly distributed. In particular, coma and lack of protective reflexes were more than twice as frequent in the latter group. When assessed for extubation readiness, primarily extubated patients had a higher GCS and a lower sqAS, and formal REC were also more frequently met in them than in patients needing primary TT. Extubated patients had shorter ventilation duration and less need for antibiotics. The LOS was shorter and outcome at discharge was better in this group.

Successful Extubation versus EF

Out of 98 primarily extubated patients, 36 (37%) were reintubated (Table 2). The mean time to reintubation was 20.8 ± 22.4 h from extubation attempt. Main reasons for reintubation were severe dysphagia with aspiration (36%), severely decreased level of consciousness (25%), elevated ICP (22%), respiratory failure (including upper airway swelling; 11%), and severe hemodynamic instability (6%). Univariate ANOVA revealed no significant differences of time to reintubation for these subgroups ($p = 0.249$), indicating that early EFs were not more likely due to a particular cause than later failures. In univariate comparison, reintubation was significantly more likely in patients in need of neurosurgical intervention. The sqAS and GCS scores noted directly prior to the extubation attempt were more severe in patients reintubated later on, although absolute differences were small resulting in a large overlap between groups. Interestingly, fulfillment of REC, duration of sedation, and artificial ventilation did not differ. With regards to in-hospital outcome reintubated patients had more bronchopulmonary infections, longer periods of sedation and artificial ventilation, higher mRS score at discharge, and longer ICU- and in-hospital-LOS. Binary logistic regression analysis evaluating predictors of EF showed that only prior neurosurgical treatment (OR 15.8, 95% CI 3.1–80.5, $p < 0.001$) and the sqAS (OR 1.4, 95% CI 1.07–1.96) prevailed as independent factors, whereas age, NIHSS on admission, GCS prior to extubation, and the patient's ability to follow commands were not significantly related to this complication in multivariate analysis.

Table 1. Comparison of patients with primary extubation vs. primary tracheostomy

Demographics	Primary extubation (n = 98)	Primary TT (n = 87)	p value
Age, years*	65.4 (15.4)	65.9 (14.0)	0.848
Gender, men, n (%)	48 (49.0)	51 (58.6)	0.167
Clinical features			
NIHSS†	15.0 (8.3)	17.0 (7.8)	0.004
Baseline GCS†	11.0 (4.0)	9.5 (10.0)	<0.001
Diagnosis, n (%)			
IS	85 (86.7)	63 (72.4)	0.015
HS	13 (13.3)	24 (27.6)	0.015
Supratentorial stroke	81 (82.7)	72 (82.8)	1.0
Infratentorial stroke	17 (17.3)	15 (17.2)	1.0
Etiology of IS, n (%)			
Atherothrombotic	17 (20)	11 (17.5)	0.696
Cardioembolic	43 (50.6)	38 (60.3)	0.240
Other known cause	10 (11.8)	1 (1.6)	0.020
Unknown	15 (17.6)	13 (20.6)	0.646
Treatment, n (%)			
i.v. thrombolysis	63 (74.1)	39 (61.9)	0.008
Thrombectomy	59 (69.4)	33 (52.4)	0.020
Neurosurgery	20 (20.4)	45 (51.7)	<0.001
Comorbidities, n (%)			
Arterial hypertension	58 (59.2)	55 (63.2)	0.574
Atrial fibrillation	29 (29.6)	28 (32.2)	0.703
Diabetes mellitus	18 (18.4)	16 (18.4)	1.0
Smoker	19 (19.4)	17 (19.5)	1.0
Hyperlipidemia	14 (14.3)	14 (16.1)	0.732
COPD	5 (5.1)	5 (5.7)	0.846
BMI >30	3 (3.1)	15 (17.2)	0.001
Previous stroke	11 (11.2)	9 (10.3)	0.847
Reason for intubation, n (%)			
Pre-intervention	73 (74.5)	42 (48.3)	<0.001
Coma, decreased reflexes	24 (24.5)	40 (46.0)	0.002
Respiratory distress	2 (2.0)	6 (6.9)	0.105
Prior to extubation/TT			
REC fulfilled, n (%)	93 (94.8)	31 (35.6)	<0.001
GCS prior to extubation†	13.0 (1.3)	3.0 (4.8)	<0.001
Following commands, n (%)	83 (84.6)	12 (13.8)	<0.001
sqAS†	4.0 (4.0)	8.0 (3.0)	<0.001
In-hospital-outcome			
Multiple antibiotics, n (%)	17 (17.3)	37 (42.5)	<0.001
Duration of ventilation, h*	106.4 (131.1)	285.6 (175.9)	<0.001
ICU-LOS, days*	9.1 (8.1)	18.3 (10.8)	<0.001
In-hospital-LOS, days*	16.6 (13.0)	23.7 (14.0)	0.001
mRS†	4.0 (2.0)	5.0 (1.0)	<0.001

COPD, chronic obstructive pulmonary disease; GCS, Glasgow Coma Scale; ICU, intensive care unit; IS, ischemic stroke; HS, hemorrhagic stroke; LOS, length of stay; mRS, modified Rankin Scale; NIHSS, National Institute of Health Stroke Scale; REC, respiratory extubation criteria; sqAS, semi-quantitative airway score; TT, tracheostomy. Continuous variables (*) are expressed as mean (SD), ordinal variables (†) as median (interquartile range).

Discussion

This is – to the best of our knowledge – the first prospective observational study investigating airway management decisions in a selected cohort of intubated acute stroke patients.

The first main finding is that the group of patients being primarily tracheostomized was clearly distinct from the group of patients being primarily extubated: primarily tracheostomized patients were more obese, had more severe strokes, had lower level of consciousness with decreased protective reflexes as main reason for intubation,

Table 2. Comparison of patients with successful extubation vs. reintubation

Demographics	Successful extubation (*n* = 62)	Reintubation (*n* = 36)	*p* value
Age, years*	65.9 (15.0)	64.6 (16.2)	0.696
Gender, men, *n* (%)	29 (46.8)	19 (52.8)	0.566
Clinical features			
NIHSS†	15.0 (7.0)	13.5 (11.0)	0.610
Baseline GCS†	12.0 (4.3)	11.0 (5.8)	0.089
Diagnosis, *n* (%)			
IS	56 (90.3)	29 (80.6)	0.169
HS	6 (9.7)	7 (19.4)	0.169
Supratentorial stroke	49 (79.0)	32 (88.9)	0.214
Infratentorial stroke	13 (21.0)	4 (11.1)	0.214
Treatment, *n* (%)			
i.v. thrombolysis	42 (67.7)	21 (58.3)	0.349
Thrombectomy	42 (67.7)	17 (47.2)	0.045
Neurosurgery	6 (9.6)	14 (38.9)	<0.001
Prior to extubation			
Sedation prior to extubation, h*	33.5 (52.6)	23.3 (27.2)	0.216
Ventilation prior to extubation, h*	44.3 (54.3)	37.7 (35.7)	0.468
Antibiotic therapy, *n* (%)	16 (25.8)	18 (50.0)	0.015
REC fulfilled, *n* (%)	58 (93.5)	35 (97.2)	0.426
pO2/FiO2 >200, *n* (%)	61 (98.4)	36 (100.0)	0.443
RMV ≤12L, *n* (%)	60 (96.8)	35 (97.2)	0.903
RSBI <105, *n* (%)	59 (95.2)	36 (100.0)	0.180
GCS prior to extubation†	13.0 (2.0)	12.0 (2.0)	0.049
Following commands, *n* (%)	51 (82.3)	32 (88.9)	0.380
sqAS*, †	4.0 (3.0)	5.0 (3.3)	0.003
In-hospital-outcome			
Multiple antibiotics (>3), *n* (%)	3 (4.8)	14 (38.9)	<0.001
Pulmonary infection, *n* (%)	32 (51.6)	29 (80.6)	0.004
Sepsis, *n* (%)	1 (1.6)	1 (2.8)	0.694
Ventilation duration, h*	46.0 (59.4)	210.4 (154.5)	<0.001
ICU-LOS, days*	5.5 (4.8)	15.4 (8.7)	<0.001
In-hospital-LOS, days*	12.6 (7.6)	23.6 (16.9)	0.001
mRS†	4.0 (2.0)	5.0 (1.0)	<0.001

COPD, chronic obstructive pulmonary disease; GCS, Glasgow Coma Scale; ICU, intensive care unit; IS, ischemic stroke; HS, hemorrhagic stroke; LOS, length of stay; mRS, modified Rankin Scale; NIHSS, National Institute of Health Stroke Scale; REC, respiratory extubation criteria; RMV, respiratory minute volume; RSBI, rapid shallow breathing index; sqAS, semiquantitative airway score; TT, tracheostomy. Continuous variables (*) are expressed as mean (SD), ordinal variables (†) as median (interquartile range).

and recanalization was more often unsuccessful with greater need for neurosurgical intervention.

It is still a daily clinical dilemma to decide whether and when ventilated stroke patients should obtain a TT. Predictors that may guide the decision have been identified only in few previous studies and are quite similar to our own observations. In a retrospective study by Szeder et al. [24] on patients with intracerebral hemorrhage, GCS <9 at day 3 as well as radiological findings such as hydrocephalus, midline shift, and intraventricular hemorrhage were all associated with the need for a TT. The SETscore (stroke-related early TT score) introduced by Boesel et al. [25] was designed to screen for prolonged intubation and necessity of a TT by combining parameters related to specific neurological functions (e.g., dysphagia and GCS <10), to the site and size of brain lesions (e.g., brainstem lesion, hydrocephalus, intracranial hemorrhage volume >25 mL) and to general organ function and procedures respectively (e.g., neurosurgical intervention, sepsis, additional respiratory disease). In a recent validation study, the SETscore predicted TT with a sensitivity of 64% and a specificity of 86% [24, 26].

With regard to the in-hospital outcome, our data are also in line with the literature [26] and support that the need for a TT is related to increased durations of sedation and ventilation, a prolonged ICU-LOS, and a worse functional outcome. Taken together, the agreement of our own data with known facts from the literature suggests that from a clinical perspective, the group of primarily extubated patients can reasonably be differentiated from patients deemed to be in need for a TT.

Duration of ventilation was substantially shorter in successfully extubated patients as compared to tracheostomized patients. There continues to be controversy regarding the optimal timing of TT. Performing an early TT in neurologic ICU patients may reduce long-term mortality, duration of ventilation, and ICU-LOS [27]. In an earlier study, Koh et al. [28] even reported that patients undergoing elective tracheostomies at earlier time points had shorter ICU stays compared with patients who were given extubation trials before TT. This was not the case in our study. When compared to patients with unsuccessful extubation trials, our primary tracheostomized patients still had longer ventilation duration, longer ICU-LOS, and needed multiple antibiotics more often. This might be an argument in favor of extubation trials before performing a TT too early. However, as mentioned before, these patient groups differed substantially in their clinical characteristics, rendering direct comparisons difficult. In our study, TT was performed early if extubation could not be achieved or was not feasible. As reflected by our relatively high TT rate of 47%, a strategy of early TT naturally increases the proportion of patients undergoing this procedure.

The second main finding of our study is that only few clinically relevant differences between patients with successful extubation and those needing reintubation prevailed in multivariate analysis. Reintubated patients had received a neurosurgical intervention and antibiotic treatment significantly more often. Apart from that, the level of consciousness was significantly more decreased in patients with later EF, although this difference was marginal (<1 point on the GCS scale) and GCS levels were generally high in this collective, making this finding less convincing. Interestingly, the sqAS was the only other clinical parameter that correlated with EF. No differences were found for the ability to follow simple commands and, in particular, classical extubation criteria were fulfilled by the vast majority of patients independent of the requirement for later reintubation. Our EF rate was within the upper range of what has been reported for neurological ICU collectives [16].

Since both delayed and premature extubation increase the rate of complications and even mortality in ICU patients [6–10], it is crucial to predict whether and when to extubate. In line with our results, several studies have shown that traditional weaning and extubation parameters (such as negative inspiratory force, forced vital capacity, RSBI and pO2/FiO2) are not very reliable in neurocritical care patients, a population with lower incidence of primary lung pathology [29–32]. One of the most illustrative evidence for this assumption is probably provided by a prospective observational study by Anderson et al. [31] on 285 extubations carried out on 339 neuro-ICU patients with different neurological diseases (including stroke) yielding a reintubation rate of 16.8%. Here, the 4 recorded traditional weaning parameters (tidal volume, breathing rate, RSBI, and pO2/FiO2) were nearly identical between the subgroups of successful and failed extubation. Due to these observations, more recent research in neurological ICU patients focused on non-respiratory parameters to predict EF. The level of consciousness at the moment of extubation received some attention, since pathophysiologically, a depressed mental status is considered to be a risk factor for the inability to protect the airway [33]. A considerable number of studies devoted to this aspect, however, yielded controversial results. For instance, in a recent meta-analysis, Wang et al. [16] specifically looked for predictors of EF in neurocritical care patients and identified a low GCS (7–9) as being associated with a nearly 5-fold increased risk of reintubation. However, other studies in neurological ICU patients did not support this finding [23, 30, 34]. Remarkably, in one study, even 10 of 11 patients with a GCS ≤4 were successfully extubated [23]. Another clinical parameter closely related to the level of consciousness is the patient's ability to follow commands. Again, the meta-analysis by Wang et al. [16] found a more than twofold increase in risk for EF if patients were not able to follow commands. In line with this, a study by Salam et al. [35] suggested that the patient's ability to follow 4 specific commands was associated with a higher probability of extubation success. This was also confirmed by the prospective study by Anderson et al. [31] mentioned above. However, other studies again could not support this association [36–38] that was also assessed critically by a recent positional statement [33]. Most of these studies, however, involved very heterogeneous neurological pathologies. Our data add only little to this controversy, since GCS values were comparatively high in both groups and most patients were able to follow commands, irrespective of the necessity of later reintubation. Hence, we assume that the level of consciousness on its own may not be a reliable criterion to base extubation decisions on inventilated stroke patients.

It is quite likely that clinical parameters more closely related to airway safety better help to predict successful extubation. The most obvious and probably best studied aspect is to assess the patient's ability to cough. Different assessment methods have been evaluated. Coughing has been graded according to the clinically observed level of cough strength, usually qualitatively differentiating between 3 and 4 grades [39, 40], by using a qualitative marker of cough efficiency like the "white card test," which evaluates the patients ability to cough secretions onto a card held in a short distance from the tube [41], or by adopting the technically more sophisticated quantitative measurement of cough peak flow with a pneumotachograph or a peak flow meter [32, 35]. Irrespective of the method chosen, most studies have revealed that patients with a weak cough were at increased risk of EF [30, 32, 35, 40–42]. More specifically, Thille et al. [39] in their large prospective study suggested that reduced cough strength is associated with a 5-fold increased risk of reintubation, and that cough strength is even more important for extubation success than peripheral weakness. As was observed with cough strength, quantity and/or quality of endotracheal secretion were also closely related to EF in several studies [31, 35, 39, 41, 43, 44] with attributed risk increases ranging from 2 [31] to 12 [44].

Taking into account the clinical impact of parameters being related to airway safety the approach of Coplin et al. [23] to combine these parameters in a single airway care score seems reasonable. The authors suggested a simple qualitative 4-step rating of spontaneous cough, gag, suctioning frequency as well as sputum quantity, viscosity, and character to give a thorough assessment of protective reflexes and secretions load by a score ranging from 0 (best) to 18 (worst). In their prospective study on 136 patients with different kinds of brain damage, those with delayed extubation had higher airway scores than patients with earlier extubation. Interestingly, reintubation rates in both groups were similar (17.2 vs. 18.9%) and reintubation was not related to their airway score [23]. In contrast to these findings and in line with the above cited evidence concerning cough reflex and secretion rating, we found a significant association of our slightly modified sqAS with EF, which even prevailed in logistic regression analysis when corrected for other known risk factors. However, this finding needs to be interpreted with caution, since the absolute sqAS difference between both groups was small.

Finally, corroborating extensive evidence from the literature [8, 15, 40, 45], our study showed that EF is associated with worse global outcome. It is very likely that most of the observed associations in the patients in need for reintubation such as infectious complications, more frequent need for antibiotic treatment, longer sedation and ventilation times, and longer ICU-LOS may represent a chain of complications impacting that overall finding.

Our trial has some limitations. The 2-center design restricts generalizability. Because treatment decisions in this observational study were at the discretion of the neurointensive care physician in charge, results may be biased by variabilities in local ICU culture, for example, for early vs. late TT, or routine performance of breathing trials. Moreover, the qualitative estimates of the sqAS are subjective. Finally, our outcome assessment was directed at short-term ICU features rather than long-term results. Differences in the patients' long-term outcomes with respect to airway management decisions need to be addressed in further studies.

Conclusions

In summary, our study suggests that airway management decisions in intubated stroke patients represent a considerable clinical challenge for the intensivist. While the decision for a primary TT may be backed by few multidimensional scores, it appears much more difficult to identify candidates for primary extubation. In this regard, classical weaning parameters are not predictive of extubation success and even parameters reflecting the patient's level of consciousness and ability to cooperate seem of limited value in this population. Probably, criteria more closely related to airway safety, such as quality of cough and quantity of bronchial secretions provide the most relevant information and should therefore be assessed by specific clinical scores, like the sqAS. However, since even such an instrument in this study did not sufficiently differentiate groups of patients with extubation success from those with EF, further prospective research is clearly needed. The ideal tool should reliably separate stroke patients being ready for extubation from those who are not, but without pursuing an overly cautious approach to extubation to prevent an undesirably high TT rate.

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Erratum

In the article by Steidl C, Boesel J, Suntrup-Krueger S, Schoenenberger S, Al-Suwaidan F, Warnecke T, Minnerup J, Dziewas R entitled "Tracheostomy, Extubation, Reintubation: Airway Management Decisions in Intubated Stroke Patients" [Cerebrovasc Dis 2017;44:1–9, DOI: 10.1159/000471892], a few misspellings and omissions occured which need correction:

1. The author names Boesel J and Schoenenberger S have to be corrected. In addition, the study was done on behalf of a study group. Therefore, the authors shall be listed as follows:

Steidl C, Bösel J, Suntrup-Krueger S, Schönenberger S, Al-Suwaidan F, Warnecke T, Minnerup J, Dziewas R on behalf of the Initiative for German Neuro-Intensive Trial Engagement (IGNITE)

2. The footnote on the title page of the PDF shall read correctly as follows:

C.S. and J.B. contributed equally to this work.