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CRITICAL CARE

Association between tracheostomy timing and outcomes for older critically ill COVID-19 patients: prospective observational study in European intensive care units

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Abstract

Background: Tracheostomy is performed in patients expected to require prolonged mechanical ventilation, but to date optimal timing of tracheostomy has not been established. The evidence concerning tracheostomy in COVID-19 patients is particularly scarce. We aimed to describe the relationship between early tracheostomy (≤ 10 days since intubation) and outcomes for patients with COVID-19.

Methods: This was a prospective cohort study performed in 152 centres across 16 European countries from February to December 2020. We included patients aged ≥ 70 yr with confirmed COVID-19 infection admitted to an intensive care unit, requiring invasive mechanical ventilation. Multivariable analyses were performed to evaluate the association between early tracheostomy and clinical outcomes including 3-month mortality, intensive care length of stay, and duration of mechanical ventilation.

Results: The final analysis included 1740 patients with a mean age of 74 yr. Tracheostomy was performed in 461 (26.5%) patients. The tracheostomy rate varied across countries, from 8.3% to 52.9%. Early tracheostomy was performed in 135 (29.3%) patients. There was no difference in 3-month mortality between early and late tracheostomy in either our primary analysis (hazard ratio [HR]=0.96; 95% confidence interval [CI], 0.70–1.33) or a secondary landmark analysis (HR=0.78; 95% CI, 0.57–1.06).

Conclusions: There is a wide variation across Europe in the timing of tracheostomy for critically ill patients with COVID-19. However, we found no evidence that early tracheostomy is associated with any effect on survival amongst older critically ill patients with COVID-19.

Clinical Trial registration: ClinicalTrials.gov NCT 04321265.

Keywords: COVID-19; healthcare; intensive care units; mechanical ventilation; outcome assessment; tracheostomy

Editor's key points

- There was wide variation between European countries in terms of both the number of older patients who receive tracheostomy, and the timing of the procedure.
- There was no association between the timing of tracheostomy and patient outcomes in this prospective observational study.
- Clinicians should base decisions on when and if to perform a tracheostomy on the assessments of individual patients.

Severe coronavirus disease (COVID-19) frequently causes respiratory failure, and up to one in 20 affected patients requires admission to the ICU.^{1–3} Increasing age, co-morbid disease, and frailty are all associated with poor patient outcomes.^{4,5} There are limited data describing outcomes amongst older patients with COVID-19 treated in ICU, and many aspects of the clinical management in this population remain unclear, including the optimal timing of tracheostomy. This issue is even more important considering the relation of frailty with not only increased need for tracheostomy, but also higher in-hospital mortality after tracheostomy among mechanically ventilated patients.⁶

In patients who are expected to require prolonged mechanical ventilation, tracheostomy has several advantages, including reduced work of breathing, easier suctioning, reduced risk of accidental extubation, improved rehabilitation, oral hygiene, and patient comfort.⁷ To date, the optimal timing of tracheostomy has not been established. The evidence on mortality benefit from early tracheostomy is conflicting, with a significant variation in the direction and magnitude of effect between studies that assessed outcomes of patients requiring

tracheostomy using different lengths of follow-up period.⁸ Indications for tracheostomy in COVID-19 are similar to the general critically ill population, but evidence about the risk/benefit ratio and the optimal timing for this procedure is lacking.

As part of a multicentre, prospective observational study of older mechanically ventilated patients, we studied the rate and timing of tracheostomy amongst critically ill patients with confirmed COVID-19. Our aim was to explore associations between tracheostomy rate and timing, and patient outcomes.

Methods

Design and setting

COVID-19 disease in Very old Intensive care Patients (COVIP) was a prospective multicentre study that enrolled consecutive patients admitted to ICU with COVID-19, confirmed with polymerase chain reaction (PCR) test (ClinicalTrials.gov, NCT 04321265). The aim of this study was to describe short-term outcomes of older critically ill patients with COVID-19. The secondary aim of the study was to investigate factors associated with outcomes in this population with a particular focus on frailty.^{5,9–11} This study was a part of the very old intensive care patients (VIP) project (www.vipstudy.org) that had been endorsed by the European Society of Intensive Care Medicine (ESICM). Patients included in this sub-study were recruited in 152 centres in 15 European countries and Israel from February 12 to December 31, 2020. The list of participating countries with numbers of centres and enrolled patients is available in [Supplementary Table S1](#). National study co-ordinators were responsible for local ethics approvals, supervision of patient recruitment, and recruitment of ICUs. We were able to recruit patients without informed consent in some countries, whereas in the remaining countries informed consent was mandatory to include patients in the study ([Supplementary Table S2](#)).

Study population

This sub-study of the COVIP study included patients aged ≥ 70 yr with confirmed SARS-CoV-2 infection admitted to the ICU who required invasive mechanical ventilation. Patients previously enrolled in the COVIP study were excluded. We aimed to recruit as many patients as possible in this observational study, and no sample size calculation was performed. Each centre aimed to recruit at least 20 patients.

Data collection

Data were collected using an online case report form (CRF). All dates were numbered sequentially from the date of ICU admission. We recorded baseline demographic and clinical characteristics of study participants. The definitions of evaluated comorbidities are summarised in [Supplementary Appendix 1](#). We gathered information about tracheostomy including timing of the procedure in days since ICU admission. Early tracheostomy was defined as performed ≤ 10 days since the tracheal intubation. This threshold was chosen by an international group of clinician-researchers within our study group. The Sequential Organ Failure Assessment (SOFA) score was calculated on admission. Frailty level before disease onset was evaluated using the nine-level Clinical Frailty Scale (CFS),^{12,13} and patients were categorised as fit (1–3 points), vulnerable (4 points), or frail (5–9 points). Patients were followed up until death or 3 months after ICU admission.

Patient outcomes

The primary outcome measure was all-cause mortality within 3 months after admission to ICU. Secondary outcome measures were ICU length of stay and duration of mechanical ventilation. Data describing patient outcomes were retrieved from the hospital electronic patient record or by telephone follow-up.

Statistical analysis

Categorical variables are presented as numbers (percentage) and compared using χ^2 test. Continuous variables are presented as medians with inter-quartile range (IQR) and compared using Mann–Whitney test. Differences in crude survival between the groups were evaluated using the log-rank test. To account for immortal time bias, we performed two complementary survival analyses. In the primary analysis, patients were included in the survival analysis from the day of tracheostomy. In addition, we performed a landmark analysis to account for selection bias.¹⁴ In this analysis we excluded all patients who died or were weaned from the ventilator within the first 10 days after tracheal intubation. Patients were divided into early and non-early tracheostomy groups, the latter including patients with late tracheostomy and those who were mechanically ventilated and never received tracheostomy. Proportional hazard Cox regression adjusting for age, sex, comorbidities, baseline CFS, and SOFA scores was performed to assess the association between tracheostomy timing and 3-month mortality in both analyses. A sensitivity analysis was performed using a multivariable model with tracheostomy timing as a continuous variable (number of days from intubation to tracheostomy) with restricted cubic splines (four knots located at the 5th, 35th, 65th, and 95th percentiles of the distribution) allowing for non-linearity in the relationship between the timing of

tracheostomy and mortality. All models satisfied the proportional hazard assumption. Differences between the groups in duration of mechanical ventilation and ICU length of stay were compared in both univariate analysis (Mann–Whitney test) and multivariable analysis performed using linear regression adjusting for age, sex, comorbidities, baseline CFS, and SOFA scores. This was a complete case analysis; patients lost to follow-up were excluded. A two-sided P value < 0.05 was considered statistically significant. Statistical analyses were performed using R 3.2.3 software (R Development Core Team, Vienna, Austria).

Results

Study population

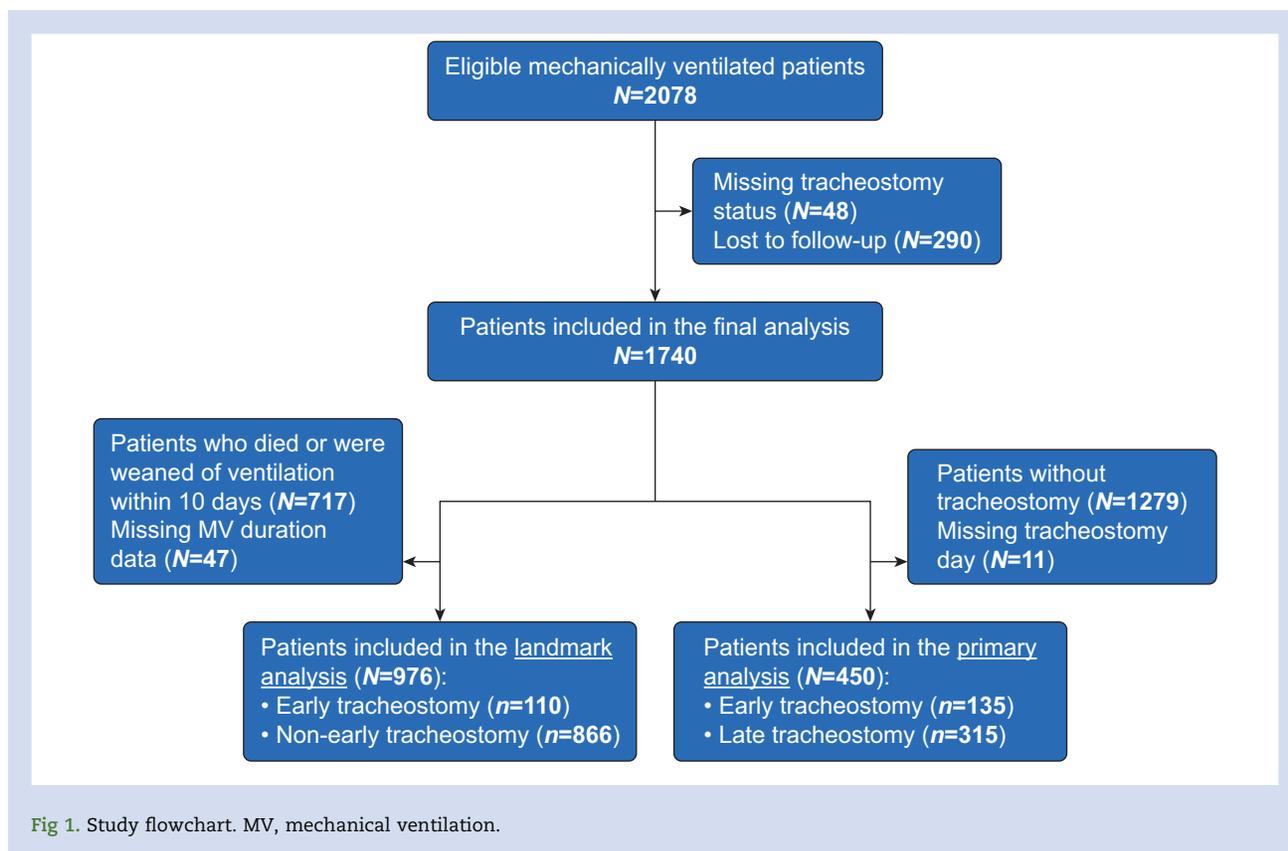
We included 2078 patients recruited in 152 centres across 16 countries with a median number of patients enrolled per centre of 8.5 (IQR, 4.0–19.25). Tracheostomy status was recorded in 2030 patients (97.7%). The final analysis was performed among patients with available data on 3-month survival status (1740/2030, 85.7%). The study flowchart is presented in [Fig 1](#). The mean age was 74 yr (IQR, 72–78) and males comprised 72.7% of the study group (1265/1740). The median SOFA score on admission was 6 (IQR, 4–8). Detailed information about patients' baseline demographic and clinical characteristics is presented in [Table 1](#).

Tracheostomy rate, timing, and characteristics of patients

Tracheostomy was performed in 461 (26.5%) patients, a median of 14 days (IQR, 9–20.5) from tracheal intubation. Tracheostomy rate varied between the countries and ranged from 8.3% in Ireland to 52.9% in Denmark. The median interval between intubation and tracheostomy also varied across countries and was lowest for Ireland (3 days) and the highest for the Netherlands and France (22 days). Tracheostomy was performed early (≤ 10 days from intubation) in 29.3% patients (135/461), and this proportion ranged from 0.0% in Austria, Israel, Portugal, and Wales to 61.5% in England and 100.0% in Ireland (only one patient with tracheostomy included and one early tracheostomy recorded). Rates of tracheostomy, early tracheostomy, and median time from intubation to tracheostomy stratified by country are summarised in [Fig 2](#) and [Supplementary Table S1](#). Analysis of tracheostomy and early tracheostomy rates in each month of the study did not reveal any apparent temporal trend ([Supplementary Fig. S2](#)).

Univariable comparison of patients who did and did not receive a tracheostomy

Patients with tracheostomy compared with those who received invasive mechanical ventilation, without tracheostomy, were more often male (77.0% vs 71.1%, $P=0.018$), were slightly younger (74.0 vs 75.0, $P=0.008$), less frequently suffered from congestive heart failure (10.3% vs 14.1%, $P=0.046$), and more frequently ventilated in the prone position (67.8% vs 52.6%, $P<0.001$), vasopressors (95.7% vs 92.5%, $P=0.028$), renal replacement therapy (26.7% vs 19.4%, $P=0.001$), steroids (73.6% vs 61.7%, $P<0.001$), and antibiotics (98.5% vs 94.8%, $P=0.001$). Three-month mortality was lower among patients with tracheostomy compared with other mechanically ventilated patients (50.3% vs 69.7%, log-rank $P<0.001$). Comparison of



patients with tracheostomy and other invasively ventilated patients is presented in [Table 1](#).

Association between early tracheostomy and clinical outcomes

Survival analysis was performed in 450 patients with tracheostomy and known tracheostomy timing and survival status at 3 months since the admission to the ICU. The 3-month mortality in the analysed subgroup was 50.4% (227/450). We found no difference in 3-month mortality between early (defined as performed ≤ 10 days since the tracheal intubation) and late tracheostomy groups (52.6% vs 49.5%, log-rank $P=0.9$). A multivariable analysis did not demonstrate any effect of tracheostomy timing on 3-month mortality (hazard ratio [HR]=0.96; 95% confidence interval [CI], 0.70–1.33). The landmark analysis revealed similar findings (HR=0.78; 95% CI, 0.57–1.06). Adjusted survival rate curves are presented in [Fig. 3](#). Detailed results of survival analysis in both primary and landmark analyses are summarised in [Table 2](#). Comparison of patients included in, and excluded from, the landmark analysis is presented in [Supplementary Table S3](#). These findings were further confirmed by our sensitivity analysis, using a multivariable model with tracheostomy timing as a continuous variable, which showed no association between tracheostomy timing and 3-month mortality. Results of a sensitivity analysis evaluating an association of number of days between intubation and tracheostomy and 3-month mortality are presented in [Supplementary Fig. S1](#). Duration of ICU length of stay and mechanical ventilation were assessed separately in primary and landmark analyses using linear regression adjusting for

age, sex, comorbidities, baseline CFS, and SOFA scores. In the primary analysis, the early tracheostomy group was characterised by a shorter ICU length of stay (β coefficient=−251.8 h; 95% CI, −352.6 to −151.0) and mechanical ventilation duration (β coefficient=−225.4 h; 95% CI, −300.6 to −150.1) compared with the late tracheostomy group. Conversely, the landmark analysis showed no statistically significant association between the timing of tracheostomy and ICU length of stay (β coefficient=44.2 h; 95% CI, −136.0 to 224.3) and mechanical ventilation duration (β coefficient=25.7 h; 95% CI, −38.2 to 89.6).

Discussion

In this prospective observational study of mechanically ventilated patients with confirmed COVID-19 aged ≥ 70 yr, there was wide variation in tracheostomy rate and timing across participating countries. We did not find evidence that tracheostomy was associated with any advantage in terms of 3-month mortality, ICU length of stay, or duration of mechanical ventilation.

Even though tracheostomy was introduced to ICUs in the 1950s, uncertainties around the procedure remain, particularly regarding indications for tracheostomy and optimal timing.^{15,16} There is a lack of high-quality evidence to define the optimal use of tracheostomy in COVID-19 patients and concerns about the safety of medical personnel during this aerosol-generating procedure.¹⁷ Initial guidelines recommended that tracheostomy be preferably performed only in patients with a negative SARS-CoV-2 swab test,¹⁸ but it has been subsequently suggested that delaying tracheostomy

Table 1 Study group characteristics and comparison of patients with tracheostomy in whom data on 3-month mortality was available. CFS, Clinical Frailty Scale; SOFA, Sequential Organ Failure Assessment; SD, standard deviation.

Characteristic	Entire cohort (n=1740)	No tracheostomy (n=1279)	Tracheostomy (n=461)	P-value	Early tracheostomy (n=135)	Late tracheostomy (n=315)	P-value
Age [yr], mean (SD)	74.0 (72.0, 78.0)	75.0 (72.0, 78.0)	74.0 (72.0, 77.0)	0.008	74.0 (71.0, 76.0)	74.0 (72.0, 77.0)	0.384
Female sex	475 (27.3)	369 (28.9)	106 (23.0)	0.018	27 (20.0)	75 (23.8)	0.446
BMI (kg m ⁻²)	27.6 (24.9, 30.7)	27.7 (25.0, 30.8)	27.4 (24.9, 30.2)	0.570	27.68 (24.64, 29.93)	27.29 (24.94, 30.58)	0.919
Prior hospitalisation (days)	2.00 (1.0, 5.0)	2.0 (1.0, 5.0)	2.0 (1.0, 5.0)	0.169	2.00 (1.00, 4.00)	2.00 (1.00, 5.00)	0.917
Duration of symptoms before hospitalisation (days)	7.00 (4.0, 10.0)	7.0 (4.0, 9.0)	7.0 (4.0, 10.0)	0.175	7.00 (4.00, 10.00)	7.00 (4.00, 10.00)	0.589
Diabetes mellitus	575 (33.2)	439 (34.5)	136 (29.5)	0.059	35 (25.9)	97 (30.8)	0.354
Ischaemic heart disease	354 (20.7)	270 (21.4)	84 (18.5)	0.201	20 (15.0)	63 (20.3)	0.246
Chronic renal failure	252 (14.6)	188 (14.8)	64 (14.0)	0.723	21 (15.6)	40 (12.8)	0.533
Arterial hypertension	1143 (65.8)	838 (65.7)	305 (66.3)	0.852	99 (73.3)	198 (63.1)	0.045
Pulmonary disease	373 (21.5)	282 (22.2)	91 (19.8)	0.327	26 (19.3)	64 (20.4)	0.873
Congestive heart failure	225 (13.1)	178 (14.1)	47 (10.3)	0.046	12 (8.9)	33 (10.6)	0.709
Confirmed bacterial infection	415 (24.5)	281 (22.6)	134 (29.7)	0.003	41 (31.1)	86 (27.9)	0.582
SOFA score on admission	6.0 (4.0, 8.0)	6.0 (4.0, 8.0)	6.0 (4.0, 8.25)	0.584	7.00 (4.00, 8.50)	6.00 (4.00, 8.50)	0.32
CFS score	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	0.049	3.00 (2.00, 3.00)	3.00 (2.00, 4.00)	0.384
Frailty status, n (%)				0.131			0.446
Fit (CFS 1–3)	1145 (72.1)	835 (71.2)	310 (74.7)		90 (78.3)	214 (73.8)	
Vulnerable (CFS 4)	234 (14.7)	170 (14.5)	64 (15.4)		17 (14.8)	44 (15.2)	
Frail (CFS 5–9)	209 (13.2)	168 (14.3)	41 (9.9)		8 (7.0)	32 (11.0)	
Noninvasive ventilation	343 (19.8)	268 (21.1)	75 (16.3)	0.094	22 (16.3)	51 (16.2)	1
Day of intubation	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	0.034	1.00 (1.00, 2.00)	1.00 (1.00, 1.00)	0.365
Intubation to tracheostomy interval (days)	14.0 (9.0, 20.5)	–	14.0 (9.0, 20.5)	–	6.00 (4.00, 8.50)	17.00 (13.00, 23.00)	<0.001
Prone position	977 (56.6)	670 (52.6)	307 (67.8)	<0.001	80 (59.3)	226 (72.7)	0.007
Vasopressors	1618 (93.4)	1178 (92.5)	440 (95.7)	0.028	132 (97.8)	299 (95.2)	0.316
Renal replacement therapy	370 (21.3)	247 (19.4)	123 (26.7)	0.001	39 (28.9)	81 (25.8)	0.574
Antibiotics	1667 (95.8)	1213 (94.8)	454 (98.5)	0.001	134 (99.3)	309 (98.1)	0.618
Steroids	1109 (64.9)	777 (61.7)	332 (73.6)	<0.001	81 (63.3)	242 (77.6)	0.003

beyond 14 days from the initial diagnosis may decrease the risk of transmitting the disease to healthcare workers.^{18,19} Current guidelines issued by the American College of Chest Physicians state that tracheostomy is indicated in patients with COVID-19 in whom prolonged mechanical ventilation is expected, without the requirement to routinely test for SARS-CoV-2 before the procedure.²⁰ We did not identify any temporal trends in the use of tracheostomy through the course of the pandemic. It is however possible that tracheostomy may have been performed more frequently when the number of hospitalised COVID-19 patients was lower.

Tracheostomy is performed in approximately 13% of patients with acute respiratory distress syndrome, making it one of the most common airway-related procedures in ICU.²¹ In this study tracheostomy was performed in about one-quarter of mechanically ventilated patients, which is consistent with previous reports of tracheostomy rates among critically ill

COVID-19 patients, which range from 16.4% to 53.0%.²² Another interesting observation is a large variation of tracheostomy practices across the countries included in our study, as the frequency of tracheostomy ranged from 8.3% in Ireland to 52.9% in Denmark. The variation in tracheostomy timing was even greater. Similar analyses in the pre-COVID-19 era also suggested significant differences in tracheostomy practices around the world.²¹ Importantly, non-random selection of participating ICUs could have influenced this observation as the approach to tracheostomy may vary between both hospitals and countries.²³

In the majority of clinical scenarios, tracheostomy is considered in patients who have survived the acute phase of the disease and show signs of improvement, therefore giving hope for a positive outcome.¹⁵ It is therefore not surprising that our analysis showed that patients who underwent tracheostomy have a higher survival rate compared with the

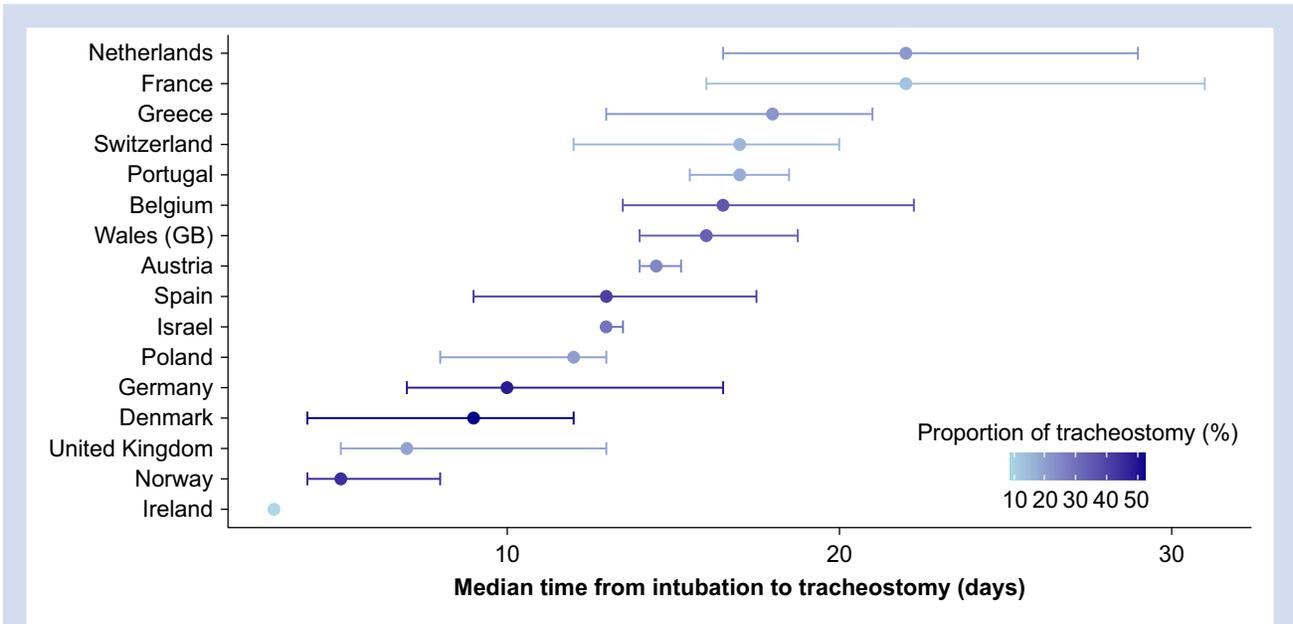


Fig 2. Cleveland plot showing median time from tracheal intubation to tracheostomy and proportion of tracheostomy stratified by country. Time from intubation to tracheostomy is presented as median (dot) and inter-quartile range (whiskers). Proportion of patients who underwent tracheostomy is shown as a shade of blue.

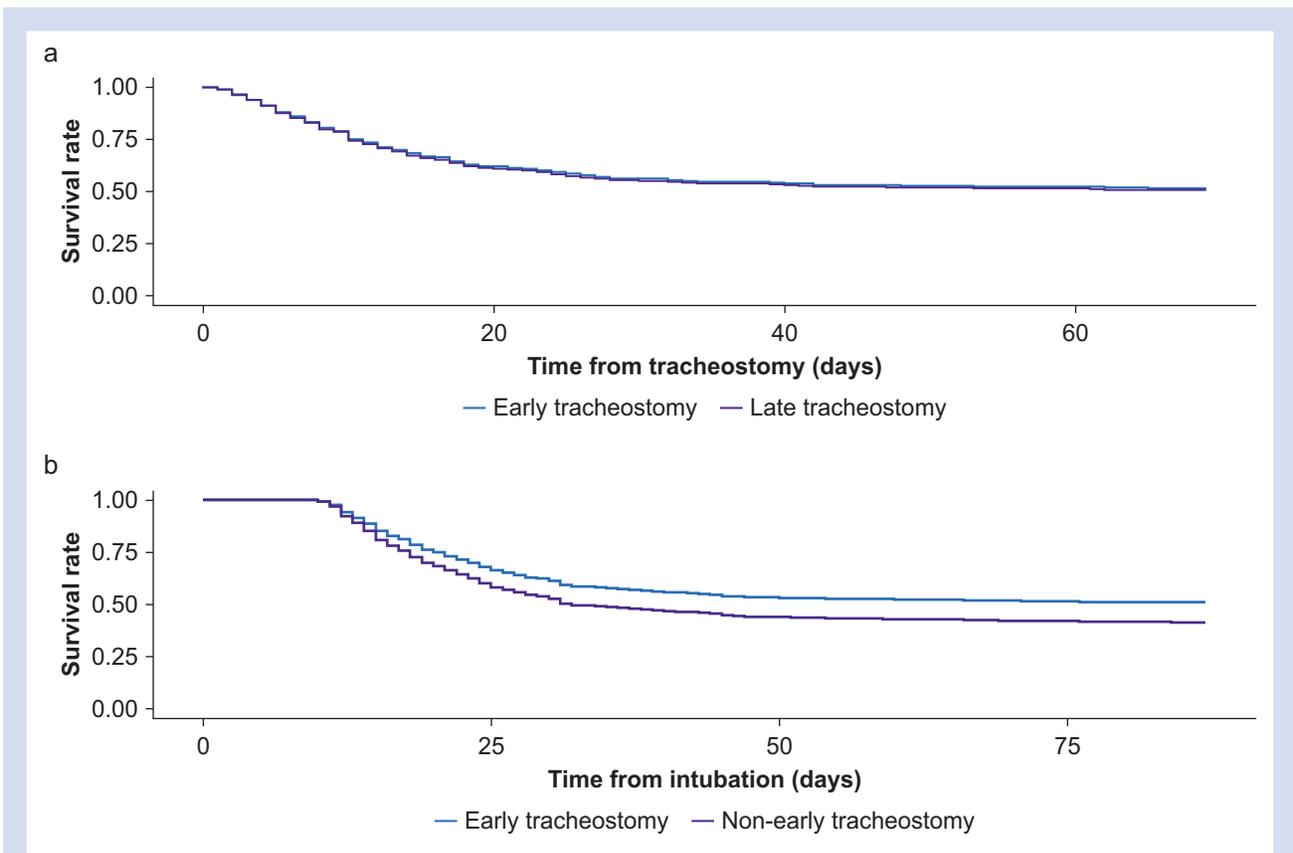


Fig 3. Adjusted survival rate curves for early tracheostomy defined as performed ≤ 10 days from tracheal intubation based on (a) primary analysis and (b) landmark analysis. The adjusted survival rates are presented for an average patient in primary and landmark analyses.

Table 2 Study outcomes. CI, confidence interval; HR, hazard ratio; MV, mechanical ventilation.

Outcome	Primary analysis			Landmark analysis				
	Early tracheostomy (n=135)	Late tracheostomy (n=315)	Unadjusted P-value	Adjusted (95% CI)	Early tracheostomy (n=110)	Non-early tracheostomy (n=866)	Unadjusted P-value	Adjusted (95% CI)
Three-month mortality	71 (52.6%)	156 (49.5%)	0.9	HR=0.96 (0.70–1.33)	58 (52.7%)	522 (60.3%)	0.095	HR=0.78 (0.57–1.06)
ICU length of stay (h)	560.0 (413.0, 856.0)	796.0 (596.0, 1128.0)	<0.001	β =−251.8 (−352.6 to −151.0)	624.0 (456.00, 943.50)	552.00 (391.25, 771.75)	0.010	β =44.2 (−136.0 to 224.3)
MV duration (h)	456.0 (312.5, 659.0)	665.5 (480.0, 888.0)	<0.001	β =−225.4 (−300.6 to −150.1)	536.50 (384.00, 708.75)	460.50 (344.25, 672.00)	0.040	β =25.7 (−38.2 to 89.6)

remaining mechanically ventilated patients. This also corroborates the results of a recently published meta-analysis suggesting that mortality is much lower amongst those COVID-19 patients who do receive a tracheostomy.²⁴

Although the topic has been widely studied, the optimal timing of tracheostomy has not yet been established. There is no consensus definition for early tracheostomy, with cut-off points ranging from <4 to ≤21 days. Observational studies are inherently prone to unmeasured confounding, whereas randomised trials are hindered by a high proportion of patients allocated to the late tracheostomy group who ultimately do not require the procedure. To account for both immortal time and selection bias, we performed two separate and complementary analyses, including landmark analysis. We have attempted to model this effect in our landmark analysis excluding patients who died or who were weaned from ventilation within 10 days from intubation, and may therefore not have been candidates for tracheostomy. Patients were divided into early and non-early tracheostomy group, with the latter including patients who did and did not undergo tracheostomy, providing a similar population to those included in intention-to-treat analyses in randomised trials.^{14,25} Both survival analyses confirmed a lack of association between the timing of tracheostomy and 3-month survival for critically ill patients with COVID-19. The findings of meta-analyses including RCTs performed before the COVID-19 pandemic suggest that early tracheostomy is associated with a lower mortality amongst patients who require prolonged mechanical ventilation.^{8,26} However, the evidence base for patients with COVID-19 consists solely of observational data. A recently published meta-analysis, including 203 patients with COVID-19 from three studies, did not show mortality benefit from early tracheostomy.²⁷ Our sensitivity analysis with timing of tracheostomy evaluated as a non-linear continuous variable did not indicate any association between tracheostomy timing and 3-month mortality. However, this observation may be affected by the improved outcomes for patients who survive the immediate phase of COVID-19 within the first few days of ICU admission. It was important to undertake this sensitivity analysis because any definition of early vs late tracheostomy will inevitably be an arbitrary choice. This approach dichotomises the dataset leading to loss of information and an increased risk of bias. We therefore encourage readers to take all the complementary analyses into consideration while drawing conclusions from this study. In our opinion, this sensitivity analysis suggests that it is unlikely that the threshold selected in our study affected the conclusions in a meaningful way. However, the need remains to create a uniform definition of early tracheostomy to facilitate the research in this area.

With regard to the effect of tracheostomy timing on the duration of mechanical ventilation and duration of ICU stay, the existing evidence suggests that early tracheostomy increases the number of ventilator-free days and reduces the duration of ICU stay.^{8,26} The primary analysis in our study showed that patients in the early tracheostomy group experienced shorter ICU stays and spent fewer hours on mechanical ventilation. However, this observation is subject to bias in the primary mortality analysis population. We undertook a landmark analysis to account for this source bias, the findings of which suggest there is no effect of tracheostomy timing and ICU stay or duration of mechanical ventilation after adjustment for potential confounders. Although a meta-analysis of previous studies including critically ill

COVID-19 patients suggest that early tracheostomy is associated with a shorter ICU stay, these findings are limited by low patient numbers and the same source of bias described above.^{24,28}

The main strength of our study is a large cohort of prospectively recruited patients with COVID-19 who underwent tracheostomy which significantly improves the quality of available evidence. Our study also has several limitations. The interpretations of observational studies evaluating timing of tracheostomy are inherently susceptible to immortal time bias and confounding. We aimed to minimise bias by including two complementary survival analyses. Our results cannot easily be generalised to the wider population of COVID-19 patients because the COVIP study only enrolled patients aged ≥ 70 yr. The low numbers of patients enrolled in some countries may result in a poor reflection of national tracheostomy practices. The consensus cut-off of ≤ 10 days that we used to define an early tracheostomy is by default arbitrary. At the same time, using a single threshold allowed us to emulate a clinical trial scenario in landmark analysis. To avoid missing relevant signals, we performed a sensitivity analysis where number of days to tracheostomy was treated as a continuous variable. Finally, we were not able to explore the effect of several factors, which may also alter patient outcomes including decannulation, sedation, time to mobilisation, incidence of delirium, and discharge destination.

In conclusion, this prospective observational study of mechanically ventilated patients aged ≥ 70 yr with COVID-19 showed wide variation in tracheostomy practices across Europe. Our findings do not show any effect of tracheostomy timing on patient mortality, duration of mechanical ventilation, or ICU length of stay.

Authors' contributions

Guarantor of the paper: WS

All authors made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; drafted the work or revising it critically for important intellectual content; approved of the final version to be published; and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declarations of interest

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Appendix A. Supplementary data

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