Published in final edited form as:

Crit Care Med. 2017 May ; 45(5): 835–842. doi:10.1097/CCM.0000000000002327.

Cumulative Probability and Time to Reintubation in United States Intensive Care Units

Andrea N. Miltiades, MD[1], **Hayley B. Gershengorn, MD**[2], **May Hua, MD**[1], **Andrew A. Kramer, PhD**[3], **Guohua Li, DrPH, MD**[1,4], and **Hannah Wunsch, MD, MSc**[1,5,6]

[1]Department of Anesthesiology, Columbia University, New York, NY, USA

[2]Department of Medicine, Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY, USA

[3]Cerner Corporation, Vienna, VA, USA

[4]Department of Epidemiology, Columbia University, New York, NY, USA

[5]Department of Critical Care Medicine, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

[6]Department of Anesthesia and Interdepartmental Division of Critical Care, University of Toronto, Toronto, Ontario, Canada

Abstract

OBJECTIVE—Reintubation after liberation from mechanical ventilation is viewed as an adverse event in intensive care units (ICUs). We sought to describe the frequency of reintubations across U.S. ICUs and to propose a standard, appropriate time cut-off for reporting of reintubation events.

DESIGN & SETTING—We conducted a cohort study using data from the Project IMPACT database of 185 diverse ICUs in the U.S.

PATIENTS—We included patients who received mechanical ventilation and excluded patients who received a tracheostomy, had a do-not-resuscitate order placed, or died prior to first extubation.

MEASUREMENTS—We assessed the percentage of patients extubated who were reintubated; the cumulative probability of reintubation, with death and do-not-resuscitate orders after extubation modeled as competing risks, and time to reintubation.

MAIN RESULTS—Among 98,367 patients who received mechanical ventilation without death or tracheostomy prior to extubation, 9,907 (10.1%) were reintubated, with a cumulative probability of 10.0%. Median time to reintubation was 15 hours (interquartile range 2–45 hours). Of patients who required reintubation in the ICU, 90% did so within the first 96 hours after initial extubation; this was consistent across various patient subtypes (89.3% for electives surgical patients up to 94.8% for trauma patients and ICU subtypes (88.6% for cardiothoracic ICUs to 93.5% for medical ICUs).

Corresponding Author: Hayley Gershengorn, MD, Albert Einstein College of Medicine, Montefiore Medical Center, 111 East 210th Street, Gold Zone, Main Floor, Bronx, NY 10467, hgershen@montefiore.org, phone: 617-834-3012.

CONCLUSIONS—The reintubation rate for ICU patients in US ICUs is approximately 10%. We propose a time cut-off of 96 hours for reintubation definitions and benchmarking efforts, as it captures 90% of ICU reintubation events. Reintubation rates can be reported as simple percentages, without regard for deaths or changes in goals of care that might occur.

MeSH KEY WORDS

Respiration; Artificial; Ventilator Weaning; Airway Extubation; Respiratory Insufficiency; Intensive Care

INTRODUCTION

Respiratory failure is a common indication for admission to intensive care units (ICUs) (1), with approximately 40% of ICU patients in the United States receiving mechanical ventilation (2, 3). Once liberated from mechanical ventilation, the need for reintubation is viewed as a potential adverse event. Requiring reintubation is associated with organ dysfunction secondary to physiologic stress (4, 5), increased mortality (4–6), higher hospital costs and longer length of ICU stay (6–10), however, if patients are maintained on the ventilator longer than is necessary, they run the risk of ventilator-associated complications, increased morbidity and also longer length of ICU stay (4, 8, 11). Therefore, having either a very high or a very low reintubation rate could negatively impact patient outcomes and represent low quality care.

Reported rates of reintubation in the literature range from 3% to greater than 30% (5, 7, 12–21). This variation can be attributed to heterogeneity of included patients, study types, but also differences in follow up periods ranging from 24 hours to over 1 week after extubation (6, 14,15, 19, 22, 23). This last aspect of variability occurs because there is no consensus for the time frame in which a need for reintubation should be tracked and reported after an initial extubation.

Given the substantial variability in estimates of reintubation rates and timeframes used, the primary aim of this study was to report the absolute percentage of patients reintubated in U.S. ICUs using a national multi-center database. We also assessed the cumulative probability of reintubation events accounting for the competing risks of death or a change in goals of care (i.e. placement of a do-not-resuscitate (DNR) order). We did this to determine whether accounting for these events in reporting substantially changes the estimate of reintubation rates. Finally, we sought to define a time window for reporting reintubation events and to identify patient and hospital-level factors associated with an increased odds of reintubation.

MATERIALS AND METHODS

We conducted a cohort study to determine the cumulative probability and timing of reintubations in U.S. ICUs using data from the Project IMPACT database from 2000 through 2009 for the primary analysis and APACHE Outcomes database from 2010 through 2012 for secondary analysis. Project IMPACT is a large, validated database of 185 diverse ICUs in the U.S. (24). Data were prospectively collected by certified data collectors at participating

ICUs and the database is managed by Cerner Corporation, Kansas City, MO. Details of the Project IMPACT database have been published previously (1, 24). For a secondary analysis of reintubation rates that accounted for non-invasive positive pressure ventilation (NIPPV) we used the APACHE Outcomes database (2010 through 2012), as it included information on NIPPV as well as invasive mechanical ventilation. However, we did not use this database for the primary analysis because it lacked information on implementation of DNR orders during the ICU stay and tracheostomy during the ICU stay. Analyses were conducted at Albert Einstein College of Medicine. Institutional Review Board approval was waived by Albert Einstein College of Medicine as these data were deidentified.

Patients and Variables

We included patients aged ≥ 18 years from 2000 through 2009 admitted to participating ICUs in the U.S. who had mechanical ventilation at any point during the ICU stay. For the primary analysis, there was no minimum duration of mechanical ventilation required for inclusion. We excluded patients who were admitted to the ICU with any limitation in life-sustaining therapy, and those who received a tracheostomy or died prior to a first extubation event. We also excluded patients for whom there was missing data on mechanical ventilation start date or DNR date (Figure 1). For cases where a patient was reintubated multiple times, or re-admitted to the ICU multiple times, only the first ICU admission with mechanical ventilation during the hospitalization was included in the analysis.

The primary outcomes were the percentage of extubated patients who were reintubated and the cumulative probability of reintubation, accounting for the competing risks of death and/or placement of a DNR order. Time of extubation was defined using the end date and time of invasive mechanical ventilation; reintubation was defined by the reinstitution of invasive mechanical ventilation following extubation at any time during the same ICU stay. Time to reintubation was recorded in hours from extubation, rounded to the nearest hour. All reintubation events during the same ICU stay were included.

Analysis

We summarized demographic and clinical characteristics for all patients, and stratified by the need for reintubation. Differences between groups were assessed using t-tests and Chi-squared tests as appropriate. We calculated the cumulative probability of reintubation with DNR and death modeled as competing risks, as these events preclude a reintubation event from occurring (25). We followed patients until the last reintubation event in the cohort (32 days following extubation) and patients were assumed to be event-free (i.e. no reintubation) after ICU discharge. We also assessed the cumulative probability of reintubation for patients stratified by ICU type (Medical, Surgical, Combined Medical/Surgical, Cardiothoracic, Neurological, Other) and patient type (medical, surgical - elective, surgical - emergent, trauma). Sensitivity analyses were performed to assess the cumulative incidence of reintubation excluding patients with a duration of mechanical ventilation of less than 12, and then less than 24 hours.

Our aim was to determine a time cut-off that was clinically significant and would capture the majority of reintubation events. After determination of a time cut-off that captured 90% of

reintubation events, we also assessed the time cut off across the sub-groups above. Finally, we examined risk factors associated with the occurrence of reintubation using the cut-off of 96 hours after extubation. We excluded patients who died or who had a DNR order placed during the first 96 hours after extubation. Clinically relevant patient and hospital-specific risk factors were assessed using hierarchical logistic regression, adjusting for clustering of patients within ICUs.

To examine the frequency of use of non-invasive positive pressure ventilation (NIPPV) after initial extubation, we used the APACHE Outcomes database, stratifying patients by any or no use of NIPPV, and also by whether or not NIPPV was instituted within 24 to 48 hours of extubation. We also assessed the relationship between use of NIPPV and the cumulative probability of reintubation and calculated the cumulative probability, accounting for the competing risk of death. Due to differences in data variables, specifically the lack of data on tracheostomy placement and institution of DNR orders, we did not combine these data with the original cohort. Database management and statistical analysis were performed using Stata 13 (StataCorp LP, College Station, Texas).

RESULTS

Cohort Characteristics

After exclusions, the primary cohort consisted of 98,367 patients in 185 ICUs who received mechanical ventilation during their ICU stay and survived their first intubation episode without tracheostomy. Details of the hospitals and ICUs contributing patients to this cohort are in Appendix Table 1 in the Supplemental Digital Content. Mean age was 58.4 ±17.9 years, 59.2% were male, 79.4% Caucasian and 50.3% were classified as non-surgical (Table 1). The most frequent indications for ICU admission were cardiovascular (30.7%) or pulmonary (27.4%) diagnoses. Most patients were admitted from the emergency room (34.8%) or perioperative setting (operating room or recovery room) (44.8%). The median duration of first mechanical ventilation episode was 1 day (interquartile range (IQR) 0.5–3.3 days).

Cumulative Probability of Reintubation

Of all patients extubated, 10.1% were reintubated during the same ICU stay. The cumulative probability for reintubation was 10.0% (95% confidence interval (CI): 9.8–10.2%) (Table 2). When stratified by type of ICU, patients in medical, surgical or combined medical/surgical ICUs had a similar cumulative probability to the overall cohort, while the cumulative probability of reintubation was substantially lower in Cardiothoracic ICUs (4.9%, 95% CI: 4.1–5.8%). Among patients with a minimum duration of 12 hours of mechanical ventilation, the cumulative probability of reintubation was 12.2% (95% CI: 12.0–12.4) and for those with a minimum duration of 24 hours of mechanical ventilation, the cumulative probability of reintubation was 14.7% (95% CI: 14.4–14.9) (Supplementary Digital Content Appendix Figure 2).

Time to Reintubation

Patients were followed until the last recorded first reintubation event at 769 hours (32 days) following extubation. The median time to reintubation was 15 hours (interquartile range (IQR) 2–45 hours). Of the 10.1% of patients who required reintubation, 76.6% did so within the first 48 hours (2 days), and 91.8% within the first 96 hours (4 days) (Figure 2). The 96-hour cutoff consistently captured approximately 90% of reintubation events across different types of patients and ICUs (Table 2), and across years (Appendix Figure 1 in the Supplemental Digital Content).

Factors associated with reintubation within 96 hours

Patients who required reintubation were slightly older (Mean age 60.1 ± 17.5 vs. 58.2 ± 17.9), had a longer duration of primary mechanical ventilation (Median days [IQR] 2.8 [0.9–6.9] vs. 0.9 [0.4–2.9], p<0.001), and longer ICU length of stay (Median days 13.4 [8.5–20.9] vs. 2.9 [1.6–5.9], p<0.001). Hospital length of stay (Median days 23 [14–35] vs. 9 [6–16], p<0.001) was significantly longer for reintubated patients and in-hospital mortality was substantially higher (21.9% vs. 7.9%, p<0.001) (Table 1).

In multivariable modeling (N=68,312), patients age 70–79 had the highest likelihood of reintubation by 96 hours (odds ratio (OR) 1.34; 95% CI 1.21–1.47, p<0.001 compared with patients <50 years) (Table 3). Compared to patients admitted for a pulmonary diagnosis those with sepsis (OR 1.23; 95% CI 1.11–1.35, p<0.001) and trauma (OR 1.59; 95% CI 1.46–1.74, p<0.001) were more likely to be reintubated, while those with cardiovascular, metabolic, renal and gastroenterological diagnoses were less likely to be reintubated. Compared to patients admitted from the emergency room, those who presented from the OR/PACU were less likely to be reintubated [OR 0.82, (CI 0.73–0.92, p=0.001)], while those presenting from the step down or telemetry unit [OR 1.55 (CI 1.38–1.74, p<0.001) or ward [OR 1.42 (CI 1.29–1.57, p<0.001) were more likely to be reintubated.

Use of non-invasive positive pressure ventilation

Using the APACHE Outcomes database from 2010–2012, 23,723 patients received mechanical ventilation and survived to initial extubation. The cohort had a mean age of 61.7±16.8 years; 55.0% were male, 79.8% Caucasian and 69% were classified as non-surgical (Appendix Table 2 in the Supplemental Digital Content), a notably higher percentage than in the primary cohort. The overall rate of reintubation was 8.1% (cumulative probability 8.0%, Appendix Table 3 in the Supplemental Digital Content) and median time to reintubation was 13.0 hours (IQR 1.2–47.2). Of patients who were extubated after a first episode of mechanical ventilation, 1,144 (4.8%) patients received NIPPV after initial extubation. Among these patients, the NIPPV was initiated within the first 24 hours after extubation in 57.4%, and within the first 48 hours in 79.7% of patients. The cumulative probability for reintubation at any time during the ICU admission was substantially higher for patients who received NIPPV following extubation (31.9%) than for those who did not (6.8%) (Supplementary Digital Content, Appendix Table 3 & Figure 3).

DISCUSSION

This is the first epidemiologic study to describe the percentage of patients requiring reintubation in United States ICUs, providing a benchmark rate of 10%. It is notable that the "crude" reintubation rate and the cumulative probability, which accounted for deaths and DNR status, were almost identical, suggesting that simple estimates that do not account for risk of death or change in code status can be used in place of more complex calculations.

The choice of a time cut-off of 96 hours consistently captured approximately 90% of reintubations across all ICU types and patient types, and over a 12-year period, suggesting it is a stable metric. We propose that the 96 hour time cut-off be used as the standard for reporting reintubation rates. However, we recognize that the choice to capture a higher percentage of reintubations is balanced against the preference to include only reintubations that can be linked to the decision to extubate, rather than a new cause of respiratory failure. As more time elapses from the extubation event, the possibility of the latter increases.

Our finding of a cumulative probability of reintubation of 10% falls well within the range of 3 – >30% previously reported in the literature (5, 11,13, 19, 26). Inclusion of many patients with short durations of mechanical ventilation who would have been excluded in prior studies explains why our estimate is slightly lower than estimates in reviews (5, 13, 22). Our median time to reintubation (15 hours) also falls in the range of previously reported median time to reintubation (13 – 36 hours) (5, 6, 11). Similar to previous reports, we found a lower cumulative probability of reintubation in cardiothoracic ICUs, likely due to the transient use of mechanical ventilation for this particular patient population in the immediate post-operative period (26). Previously reported risk factors for reintubation included age (4, 11) high Rapid-Shallow-Breathing Index (RSBI) (14, 19, 27) and pneumonia (19). We also demonstrated that age was a risk factor for reintubation, and found that patients admitted with sepsis or trauma were more likely to be reintubated.

When examining NIPPV as a "treatment" for extubation failure, Esteban *et al* found no change in reintubation rate and a possible association with higher mortality (28). Using a separate dataset (APACHE Outcomes) we were also able to assess the use of NIPPV after extubation; it is notable that the reintubation rate for patients who received NIPPV was very high (almost 30%) compared with the overall rate. One must interpret this finding with caution, as this is likely due to the fact that patients who are either perceived as high risk for reintubation, or exhibit difficulty are the ones who may receive NIPPV as an attempted "bridge" to avoid reintubation (29, 30). Our findings do not assess whether NIPPV as a treatment was a successful method to avoid reintubation in this population, or impacted mortality.

Our study has a number of limitations. The observational study design using a large database limits analysis to variables pre-existing in the database. Data on the etiology of respiratory failure, other specific risk factors, such as details of the cardiac or pulmonary disease status, and the indication for reintubation were not available. It is possible that the risk factors we have identified from multivariable analysis (table 3) may contribute less than other unmeasured variables that we could not include in the model. Our results also may not be

generalizable to smaller community hospitals; Project IMPACT has an over-sampling of large community hospitals and academic medical centers. Our study includes data from 2000–2009 for Project IMPACT and 2010–2012 for APACHE Outcomes. The cumulative probability of reintubation in the years 2010–2012 was 2% lower (10% vs. 8%), possibly reflecting overall reduced rates of reintubation with changes in clinical practice. It is also possible that in the time period from 2012 to 2016 other changes in practice may have influenced the rates of reintubation. In particular, the increasing interest in and use of high flow nasal cannula oxygen could have an impact (31, 32). We also assumed that patients were event-free on ICU discharge, which could lead to an underestimation of the true reintubation probability, as patients may be discharged from the ICU and require reintubation and readmission. However, the ICU readmission rate within Project IMPACT is relatively low (4% within 120 hours of discharge), making it unlikely to affect the validity of our estimates (1).

Using a large, multi-center database, we were able to estimate both the rate and timing of reintubation in U.S. ICUs. These estimates were stable across a number of different subgroups and over time. Consequently, we propose that a reintubation rate of 10% and a 96 hour time-window for defining reintubation events be considered for use as quality benchmarks and as part of patient safety initiatives.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Brown SE, Ratcliffe SJ, Kahn JM, et al. The epidemiology of intensive care unit readmissions in the United States. American journal of respiratory and critical care medicine. 2012; 185(9):955–964. [PubMed: 22281829]
2. Esteban A, Anzueto A, Alia I, et al. How is mechanical ventilation employed in the intensive care unit? An international utilization review. American journal of respiratory and critical care medicine. 2000; 161(5):1450–1458. [PubMed: 10806138]
3. Wunsch H, Wagner J, Herlim M, et al. ICU occupancy and mechanical ventilator use in the United States. Critical care medicine. 2013; 41(12):2712–2719. [PubMed: 23963122]
4. Thille AW, Harrois A, Schortgen F, et al. Outcomes of extubation failure in medical intensive care unit patients. Critical care medicine. 2011; 39(12):2612–2618. [PubMed: 21765357]
5. Frutos-Vivar F, Esteban A, Apezteguia C, et al. Outcome of reintubated patients after scheduled extubation. Journal of critical care. 2011; 26(5):502–509. [PubMed: 21376523]
6. Epstein SK, Ciubotaru RL. Independent effects of etiology of failure and time to reintubation on outcome for patients failing extubation. American journal of respiratory and critical care medicine. 1998; 158(2):489–493. [PubMed: 9700126]
7. Seymour CW, Martinez A, Christie JD, et al. The outcome of extubation failure in a community hospital intensive care unit: a cohort study. Critical care (London, England). 2004; 8(5):R322–327.
8. Boles JM, Bion J, Connors A, et al. Weaning from mechanical ventilation. The European respiratory journal. 2007; 29(5):1033–1056. [PubMed: 17470624]
9. Thille AWRJ, Brochard L. The decision to extubate in the intensive care unit. Am J Respir Crit Care Med. 2013; 187(12):1294–1302. [PubMed: 23641924]
10. E SK. Decision to extubate. Intensive care medicine. 2002; 28(5):535–546. [PubMed: 12029399]
11. Epstein SK, Ciubotaru RL, Wong JB. Effect of failed extubation on the outcome of mechanical ventilation. Chest. 1997; 112(1):186–192. [PubMed: 9228375]

12. Rothaar RC, Epstein SK. Extubation failure: magnitude of the problem, impact on outcomes, and prevention. Current opinion in critical care. 2003; 9(1):59–66. [PubMed: 12548031]
13. Krinsley JS, Reddy PK, Iqbal A. What is the optimal rate of failed extubation? Critical care (London, England). 2012; 16(1):111.
14. Miu T, Joffe AM, Yanez ND, et al. Predictors of Re-intubation in Critically Ill Patients. Respiratory care. 2013
15. Esteban A, Alia I, Gordo F, et al. Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. The Spanish Lung Failure Collaborative Group. American journal of respiratory and critical care medicine. 1997; 156(2 Pt 1):459–465. [PubMed: 9279224]
16. Albrecht R, Naum S, Scholten D. Outcome of Patients Requiring Airway Management in Sugical Critical Illness: Use of Computer Database for Quality Assessment Critical care medicine. 1995; 23(1):A34.
17. Cohen J, Shapiro M, Grozovski E, et al. Prediction of extubation outcome: a randomised, controlled trial with automatic tube compensation vs. pressure support ventilation. Critical care (London, England). 2009; 13(1):R21.
18. Gowardman JR, Huntington D, Whiting J. The effect of extubation failure on outcome in a multidisciplinary Australian intensive care unit. Critical care and resuscitation : journal of the Australasian Academy of Critical Care Medicine. 2006; 8(4):328–333. [PubMed: 17227270]
19. Frutos-Vivar F, Ferguson ND, Esteban A, et al. Risk factors for extubation failure in patients following a successful spontaneous breathing trial. Chest. 2006; 130(6):1664–1671. [PubMed: 17166980]
20. Dries DJ, McGonigal MD, Malian MS, et al. Protocol-driven ventilator weaning reduces use of mechanical ventilation, rate of early reintubation, and ventilator-associated pneumonia. The Journal of trauma. 2004; 56(5):943–951. discussion 951–942. [PubMed: 15179231]
21. Hayashi LY, Gazzotti MR, Vidotto MC, et al. Incidence, indication and complications of postoperative reintubation after elective intracranial surgery. Sao Paulo medical journal = Revista paulista de medicina. 2013; 131(3):158–165. [PubMed: 23903264]
22. Kulkarni AP, Agarwal V. Extubation failure in intensive care unit: predictors and management. Indian journal of critical care medicine : peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2008; 12(1):1–9.
23. Rady MY, Ryan T. Perioperative predictors of extubation failure and the effect on clinical outcome after cardiac surgery. Critical care medicine. 1999; 27(2):340–347. [PubMed: 10075059]
24. Cook SF, Visscher WA, Hobbs CL, et al. Project IMPACT: results from a pilot validity study of a new observational database. Critical care medicine. 2002; 30(12):2765–2770. [PubMed: 12483071]
25. Coviello V, Boggess M. Cumulative incidence estimation in the presence of competing risks. Stata Journal. 2004; 4(2):103–112.
26. Engoren M, Buderer NF, Zacharias A, et al. Variables predicting reintubation after cardiac surgical procedures. The Annals of thoracic surgery. 1999; 67(3):661–665. [PubMed: 10215207]
27. Namen AM, Ely EW, Tatter SB, et al. Predictors of successful extubation in neurosurgical patients. American journal of respiratory and critical care medicine. 2001; 163(3 Pt 1):658–664. [PubMed: 11254520]
28. Esteban A, Frutos-Vivar F, Ferguson ND, et al. Noninvasive Positive-Pressure Ventilation for Respiratory Failure after Extubation. New England Journal of Medicine. 2004; 350(24):2452–2460. [PubMed: 15190137]
29. Evans TW. International Consensus Conferences in Intensive Care Medicine: non-invasive positive pressure ventilation in acute respiratory failure. Intensive care medicine. 2001; 27(1):166–178. [PubMed: 11280630]
30. Keenan SP, Powers C, McCormack DG, et al. Noninvasive positive-pressure ventilation for postextubation respiratory distress: a randomized controlled trial. Jama. 2002; 287(24):3238–3244. [PubMed: 12076220]
31. Hernández G, Vaquero C, González P, et al. Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients: A Randomized Clinical Trial. Jama. 2016; 315(13):1354–1361. [PubMed: 26975498]

32. Stéphan F, Barrucand B, Petit P, et al. High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in Hypoxemic Patients After Cardiothoracic Surgery: A Randomized Clinical Trial. Jama. 2015; 313(23):2331–2339. [PubMed: 25980660]

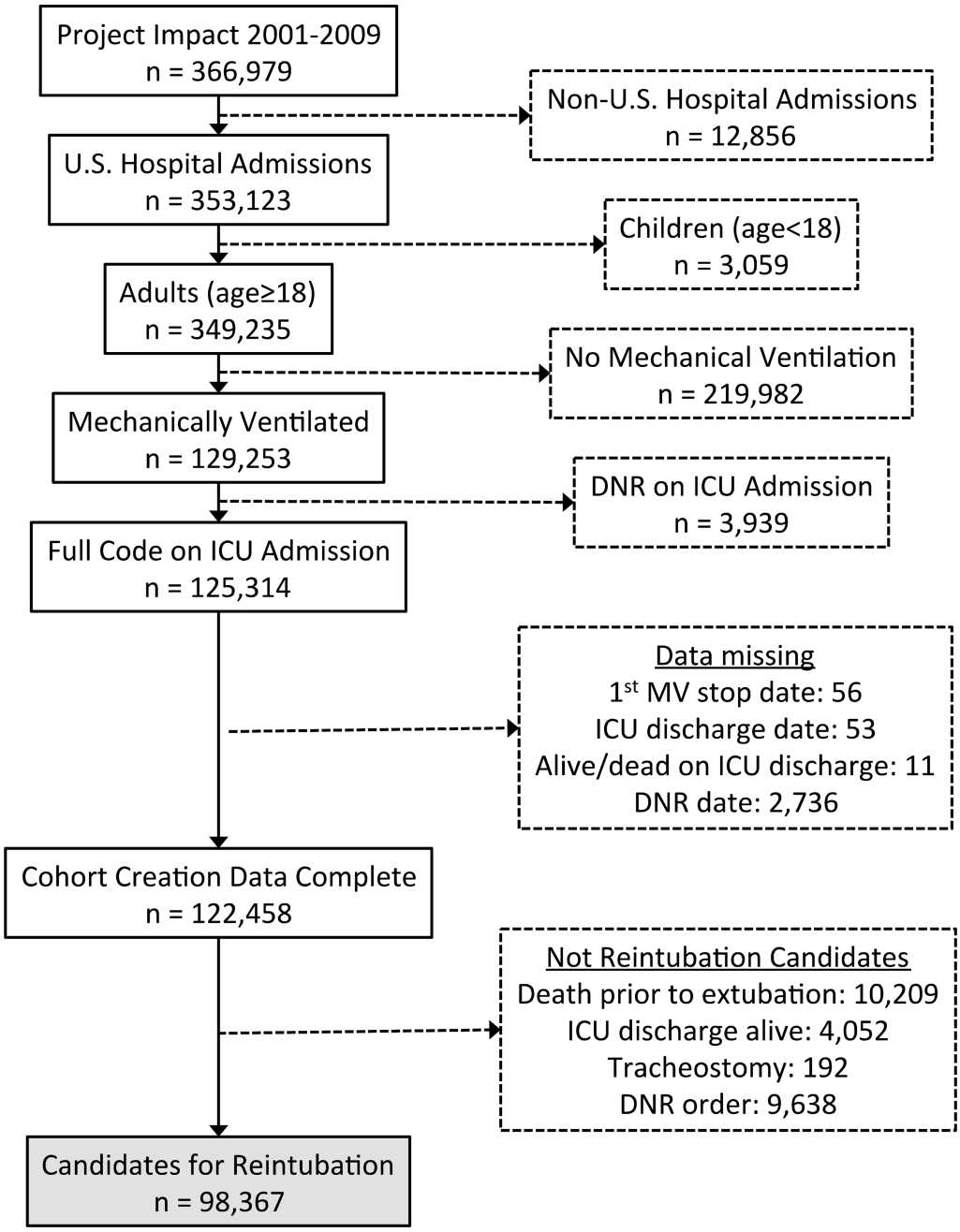

Figure 1.

Flow chart of exclusions for cohort for evaluation of reintubations in US ICUs. For cases where a patient was reintubated multiple times, or re-admitted to the ICU multiple times, only the first ICU admission with mechanical ventilation during the hospitalization was included in the analysis

Abbreviations: DNR: Do Not Rescuscitate; ICU: Intensive Care Unit.

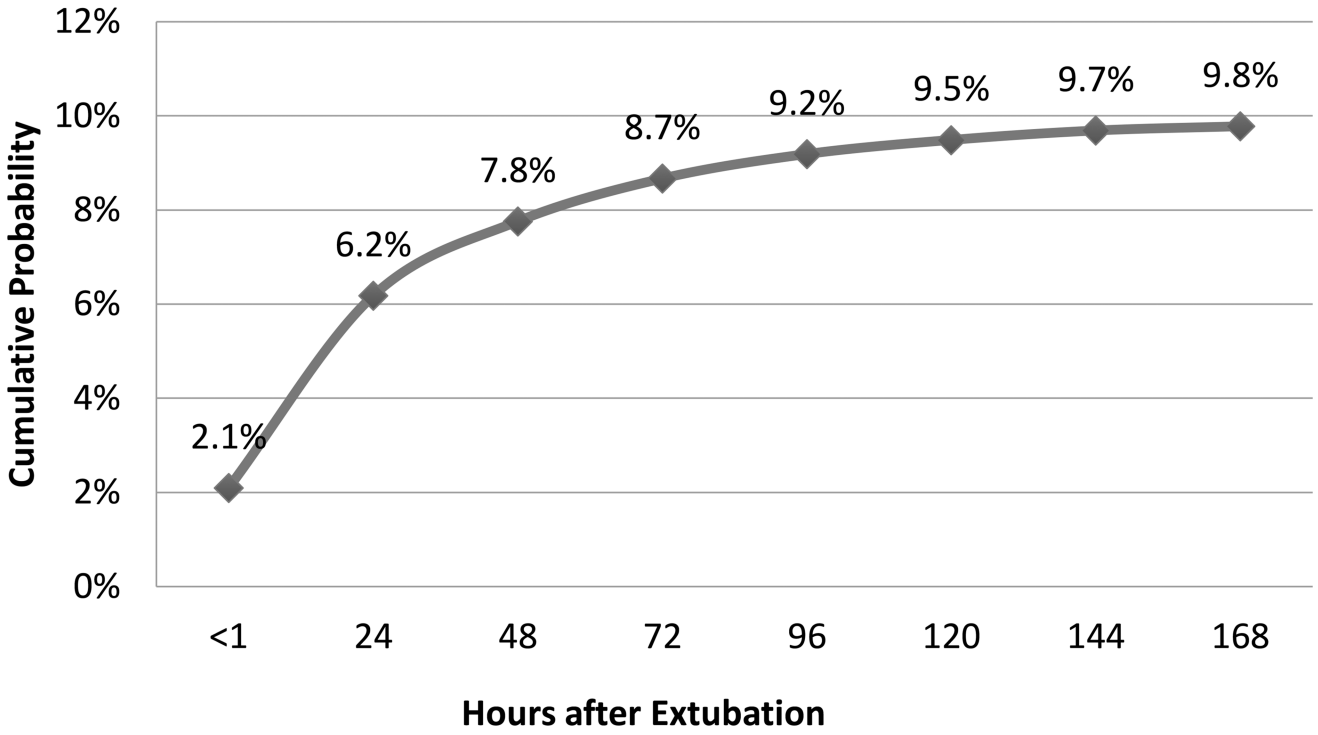

Figure 2.
Cumulative probability of reintubation over time with death and do-not-resuscitate orders modeled as competing risks

Table 1

Baseline Characteristics of cohort of patients who received mechanical ventilation and were extubated in the ICU

Variable	Total Cohort	Reintubated		*p* value
		No	Yes	
Total patients, N (%)	98,367 (100)	88,460 (89.9)	9,907 (10.1)	
Age, yrs (mean±sd)	58.4±17.9	58.2±17.9	60.1±17.5	<0.001
Gender, % male	59.20	59.23	58.91	0.54
Race %				0.012
White	79.38	79.26	80.45	
Black	13.57	13.62	13.10	
Other	7.05	7.12	6.46	
MPM_0III, mean ±sd	17.1 ±16.5	16.9 ±16.5	18.7 ±16.3	<0.001
Diagnosis Group %*				<0.001
Respiratory or Thoracic Surgery	27.38	27.08	30.11	
Cardiovascular	30.68	31.81	20.65	
Trauma	12.17	11.60	17.20	
Gastrointestinal	9.31	9.31	9.28	
Neurological	9.10	8.89	11.01	
Sepsis	5.99	5.63	9.27	
Metabolic or Renal	5.36	5.69	2.48	
Non-Surgical (%)	50.3	49.4	57.8	<0.001
Duration Mechanical Ventilation, First Episode Median (IQR)	1.0 (0.5,3.3)	0.9 (0.4,2.9)	2.8 (0.9,6.9)	<0.001
Location Prior to ICU (%)				<0.001
Emergency Room	34.8	34.8	35.2	
Operating Room or PACU	44.8	45.9	35.1	
Ward	6.5	6.2	9.1	
Step Down or Telemetry	4.2	4.0	6.4	
Other	9.7	9.2	14.2	
ICU Length of Stay, (days) median (IQR)	3.3 (1.7,7.4)	2.9 (1.6,5.9)	13.4 (8.5,20.9)	<0.001
Hospital Length of Stay, (days) median (IQR)	10 (6,19)	9 (6,16)	23 (14,35)	<0.001
ICU mortality, %	5.3	4.2	14.7	<0.001
Hospital Mortality, %	9.3	7.9	21.9	<0.001

Abbreviations:
Sd = standard deviation; MPM = mortality probability model 31; ICU = intensive care unit;
IQR =interquartile range; LOS = length of stay; PACU = post-anesthesia care unit

*APACHE diagnostic categories

Table 2

Cumulative probability and time to reintubation stratified by ICU type and patient type

Patient Group	N	Total Cumulative Probability (%)	Cumulative Probability at 96 hrs (%)	% of Total Reintubations by 96 hrs
All Patients	98,637	10	9.2	91.6
ICU Type *				
Surgical ICU	28,092	10.8	9.8	90.5
Medical ICU	10,350	9.6	9.0	93.5
Combined Medical/Surgical ICU	54,450	9.8	9.0	91.9
Cardiothoracic ICU	2,493	4.9	4.4	88.6
Patient Type				
Surgical (Elective)	28,673	6.6	5.9	89.3
Surgical (Emergent)	20,239	11.2	10.1	90.5
Medical	49,455	11.5	10.7	92.9
Trauma **	11,968	14.2	13.5	94.8

* Data for neurologic ICUs (N=195) and other or unclassified ICUs (N=3,087) not shown

** Trauma patients include both medical and surgical patients

Table 3

Multivariable logistic regression model of patient and hospital factors associated with reintubation

Variable	Odds Ratio (95% CI)	P value
Age (years)		
<50	ref	
50–59	1.24 (1.15,1.35)	<0.001
60–69	1.23 (1.13,1.34)	<0.001
70–79	1.34 (1.21,1.47)	<0.001
80+	1.13 (1.00,1.27)	0.046
Female (vs. male)	0.95 (0.90,1.00)	0.066
Race		
White	ref	
Black	0.83 (0.77,0.90)	<0.001
Other	0.83 (0.74,0.93)	0.001
MPM_0III (predicted mortality)		
<10%	ref	
10–19%	1.20 (1.12,1.29)	<0.001
20–29%	1.45 (1.33,1.58)	<0.001
≥30%	1.52 (1.40,1.65)	<0.001
Diagnostic Group *		
Respiratory or thoracic	ref	
Cardiovascular	0.85 (0.78,0.92)	<0.001
Sepsis	1.23 (1.11,1.35)	<0.001
Trauma	1.59 (1.46,1.74)	<0.001
Neurological	1.12 (1.02,1.23)	0.013
Metabolic or renal	0.49 (0.42,0.57)	<0.001
Gastroenterological	0.84 (0.76,0.93)	0.001
Location Prior to ICU Admission		
Emergency Room	ref	
OR/PACU	0.82 (0.73,0.92)	0.001
Ward	1.42 (1.29,1.57)	<0.001
Step Down or Telemetry	1.55 (1.38,1.74)	<0.001
Other	1.29 (1.18,1.41)	<0.001
Non-surgical patient (vs. surgical)	0.96 (0.87,1.06)	0.436
Type of ICU **		
Medical ICU	ref	
Surgical ICU	1.25 (0.99,1.59)	0.063
Medical/Surgical ICU	1.00 (0.81,1.23)	0.997
Cardiothoracic ICU	0.59 (0.24,1.46)	0.254

Variable	Odds Ratio (95% CI)	P value
Hospital Type		
Governmental (city/state/federal)	ref	
Community-for profit	0.96 (0.58,1.59)	0.886
Community-not for profit	1.01 (0.68,1.49)	0.978
Academic	1.37 (0.91,2.05)	0.129

Abbreviation:
MPM = mortality probability model; ICU = intensive care unit; PACU = post-anesthesia care unit; OR = odds ratio; CI = confidence interval

*APACHE diagnostic categories

**Data for neurologic ICUs (N=195) and other or unclassified ICUs (N=3,087) included in the model but not shown