Table A1.

Studies Describing Risk Factors Related to Extubation Failure

Author, (Year)	Design and Purpose	Setting	Subjects	Intervention	Outcomes
Alvarez et al., (2015)	Retrospective database analysis To identify risk factors that predict postoperative unplanned intubation at Pennsylvania Community Hospital	Pennsylvania Community Hospital	4,937 institutional ACS NSQIP data records and 1,302,281 national ACS NSQIP data records	Rate of postoperative unplanned intubation with institutional ACS NSQIP data was 1.54% compared with national ACS NSQIP data rate of 1.03%	Independent risk factors that are institutional predictors of postoperative unplanned intubation are emergent cases, preoperative ventilator status, smoking, chronic obstructive pulmonary disease and older age
Brown et al., (2011)	Prospective observational cohort To identify risk factors for failed extubation in trauma patients	University medical center in Austin, Texas	276 trauma patients	Patients who failed extubation were compared with those who were successfully extubated to identify independent risk factors for failed extubation	Failed extubations occurred in 6% of patients and mean time to failure was 15 hours Independent risk factors to fail include spine fracture, delirium tremors, initial intubation for airway reasons 18% versus 3% ($p = 0.003$) and lower GCS at extubation (9 ± 1 versus 10 ± 1, $p = 0.003$)
Brueckmann et al., (2013)	Retrospective cohort To develop and validate a score predicting reintubation in the hospital after primary extubation in the operating room, leading to unplanned mechanical ventilation	Tertiary care teaching hospital in Boston, Massachusetts	33,769 surgical cases within 29,924 patients	Using electronic anesthesia records, billing data, and chart review Patients were identified as potentially having an extubation billing code followed by evidence of respiratory service afterwards	Primary outcome was reintubation The five most common reasons identified were pulmonary edema, atelectasis, pneumonia, impaired brain function, and aspiration Each patient had multiple reasons for reintubation on average 2.3 reasons for

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	within 3 postoperative days			Patient cases were divided into a training data set group and a validation data set group Independent predictors for reintubation were: American Society of Anesthesiologists score of 3 or more, emergency surgery, high-risk surgical service, congestive heart failure history, and chronic pulmonary disease. A point value of 3, 3, 2, 2 and 1 were assigned to these predictors, based on their β coefficient in the predictive model	postextubation respiratory failure Median time to reintubation was 6.4 hours (IQR, 0.5-47.1) The score yielded a calculated area under the curve of 0.08, with a probabilities for reintubation ranging from 0.12% with a score of 0 to 5.9% for scores of 7-11
Frutos-Vivar et al., (2006)	Prospective Cohort To assess variables associated with reintubation in patients who had successfully completed a spontaneous breathing trial	37 hospitals in eight countries	900 adults in ICUs on invasive mechanical ventilation for >48 hours	Patients on invasive mechanical ventilation for >48 hours and successfully passed a spontaneous trial were followed after extubation for postextubation respiratory distress Extubation failure occurred in 121 patients Patients with respiratory distress were randomized to receive noninvasive positive pressure ventilation or usual care	Among routinely measured variables rapid shallow breathing index, positive fluid balance 24 hours prior to extubation and pneumonia as the reason to begin mechanical ventilation were best predictors of extubation failure

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Hua et al., (2012)	Retrospective database analysis To identify risk factors associated with an unplanned intubation and create a scoring tool based on the associated risk factors for assessing the potential of requiring unplanned intubation in major surgery patients	251 participating hospitals	ACS NSQIP data for years 2005-2007 with 213,548 patients, ACS NSQIP data for 2008 with 176, 031 patients	Analysis of data records for 2005-2007 identified risk factors and employed them to create a scoring system to stratify patients' risk of requiring an unplanned intubation in postoperative patients. ACS NSQIP 2008 patient data were used to validate the scoring system	Creation of the Unplanned Intubation Risk Index: variables most predictive of unplanned intubation were age (0-4 points), ASA class (0-7 points), presence of preoperative sepsis (3 points) and total operative time (0-4 points). Adjusted hazard ratios with a range lowest risk 0 to highest 18 had a 79% accuracy in identifying patients requiring unplanned intubation from those not needing unplanned intubation.
Kiekkas et al., (2012)	Clinical review of 25 cohort studies and 9 case controlled To investigate and synthesize evidence related to occurrences and consequences of unplanned extubations in ICU patients	ICU	ICU adult patients	Unplanned extubation in critically ill adults	Unplanned extubation incidence varies considerably. Agitation especially when combined with inadequate sedation and decreased surveillance are major risk factors
McCaffrey et al., (2009)	Systematic review of 14 randomized controlled trials To determine whether corticosteroids decrease the rate of	ICUs: Neonatal 2 Pediatric 4 Adult 7	2,600 ICU Patients	Two authors independently evaluated the validity of the 14 studies	Reduction in reintubation with the use of corticosteroids with pooled odds ratio of 0.56 (95% CI; 0.41- 0.77, $p < 0.0005$), effect of corticosteroids was more consistent when given at least 12

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	extubation failure				hours prior to attempted extubation Results are consistent with those of the largest RCT in this area
Menon et al., (2012)	Cohort study To investigate the occurrence and timing of extubation failure in ICU patients, to describe the associated risk factors and complications of reintubation, to estimate the adjusted mortality and additional costs associated with failed extubation	ICU municipal medical center in Washington state	2,007 ICU patients	Patients were divided into two groups based on the requirement for reintubation: "never reintubated" versus " > 1 reintubations" Data collection included baseline characteristics, ICU and hospital stay, hospital mortality, and in-patient costs were compared between patients successfully extubated and those with reintubation outside the operating room, using regression analysis	Reintubation was required in 376 (19%) and 230 (11%) were within 48 hours, primarily for respiratory failure Difficult airway at reintubation was associated with higher mortality (adjusted odd ratio 2.23, 95% CI 1.01-4.93, p = .05) Patients who were reintubated were more likely to be older, male and to have worse disease severity scores
Miu et al., (2014)	Cohort study To create a prediction model with high precision to predict extubation failure early (reintubation within first 24 hours) or at any time during hospitalization, using commonly	ICU municipal medical center in Washington state	2,007 ICU patients	Data collection included demographic, hemodynamic, respiratory, and neurological variables preceding extubation Data were compared between subjects extubated successfully and those who required reintubation	Reintubation was required in 376 (19%) of the 2007 subjects In multivariable analysis, higher Simplified Acute Physiology Score II and suctioning frequency were associated with failed extubation

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	available bedside data				
Mokhlesi et al., (2007)	Cohort study To derive a clinical prediction rule that uses bedside clinical variables to predict extubation failure within 48 hours after a successful spontaneous breathing trial	Medical and surgical ICUs at a tertiary care university hospital in Chicago, Illinois	122 medical, coronary, neurosurgical and surgical ICU patients	Patients on mechanical ventilation longer than 48 hours who did not receive a tracheostomy or undergo withdrawal of support were followed after extubation to identify those with extubation failure (reintubated within 48 hours)	Sixteen patients (13%) required reintubation within 48 hours Predicted reintubation variables: moderate to copious endotracheal secretions ($p = 0.001$), Glasgow Coma Scale ≤ 10 ($p = 0.004$), and hypercapnia during the spontaneous breathing trial ($p = 0.001$), (area under the receiver operating characteristic curve 0.87, 95% CI 0.74 – 0.94)
Politano et al., (2013)	Prospective cohort To assess complex vital sign analysis for patients who needed urgent intubation in a surgical/trauma population for 24 hours preceding intubation	Tertiary medical center, Charlottesville, Virginia	798 Surgical/Trauma ICU patients	Bedside monitors were connected to a BedMaster Ex monitoring system that records vital signs and waveform data Data were linked to stored medical record data for analysis	During the study 50 unplanned, urgent intubations occurred in 41 patients Predictive models were developed HR, RR, and SpO_2 means and RR-SpO_2 correlation coefficient had a ROC area of 0.770 (95% CI 0.712, 0.841) Increases in the risk of intubation in the following 24 hours were predicted
Ramachandran et al., (2011)	Retrospective review To describe the incidence and predictors of unanticipated post operative	ACS NSQIP database	222,094 patients undergoing nonemergent, noncardiac surgery	Data evaluation was used to determine the incidence and independent predictors of unanticipated early	49.4% of the unanticipated tracheal intubations within 30 days occurred within the first 3 postoperative days.

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	respiratory failure requiring intubation in nonemergent and noncardiac surgery			postoperative intubation	Independent predictors of unanticipated early postoperative intubation were: current ethanol use, current smoker, chronic obstructive pulmonary disease, dyspnea, diabetes requiring insulin, hypertension with medication management, active congestive heart failure, abnormal liver function, prolonged hospitalization, cancer, recent weight loss, body mass index (BMI) < 18.5 or ≥ 40 kg/m^2, medium risk surgery, high risk surgery, very high risk surgery and sepsis.
Rujirojindakul et al., (2012)	Time matched case controlled To identify risk factors for reintubation in post-anesthetic care units general surgery patients related to anesthetic processes	University tertiary care hospital in southern Thailand	820 patients	For each reintubation case (n = 164) four randomly selected controls (n = 656) that were not in the exclusion criteria were selected Anesthetic and medical records were reviewed and potential risk factors for reintubation were recorded	Risk factors for reintubation were age, <1 year, chronic pulmonary disease, preoperative hypoalbuminemia, creatinine clearance < 24, emergency case, operative time > 3 hours, airway surgery, head and neck surgery, cardiothoracic surgery, cardiac catheterization, ASA physical status III, and certain types of

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					neuromuscular blocking agent
Snyder et al., (2009)	Retrospective evaluation To investigate the incidence, risks, and prognosis of unanticipated intubation in postoperative general and vascular surgery patients.	University hospital, Birmingham, Alabama	2426 postoperative general and vascular surgery patients	Institutional NSQIP data were evaluated to identify the incidence, risk factors and prognosis of postoperative unplanned intubation	Incidence of unplanned postoperative intubation was 2.6%, significant risk factors were: dependent functional status, chronic obstructive pulmonary disease and emergent surgery
Thille et al., (2014)	Prospective observational To assess the influence of delirium, ICU-acquired paresis, and cardiac performance on extubation failure and to assess the predictive accuracy of caregivers	Teaching hospital, Creteil, France	533 Medical ICU patients	Data collection included demographics, severity score at admission, reason for intubation, duration of mechanical ventilation, ICU length of stay and outcome Patients undergoing planned extubation were categorized into groups, simple, difficult and prolonged weaning	Multivariate analysis revealed duration of mechanical ventilation longer than 7 days prior to extubation, ineffective cough, and severe left ventricular diastolic dysfunction were the 3 independent factors associated with extubation failure Reasons for reintubation were: respiratory failure (N = 21), hypercapnic coma (N = 2), respiratory arrest (N = 1), upper airway obstruction (N = 1), and shock (N = 6)