

**Appendix**

This appendix was part of the submitted manuscript and has been peer reviewed. It is posted as supplied by the authors.

## E1: Description of “early” vs. “late” tracheostomy trials

Author	Year	Setting	Patients	Study Period	Definition "Early" and "Late"	Prediction tool	Group	Total Number Patients	Number with Tracheostomy (%)	Male (%)	Age*	Illness Severity Description *
Rumbak et al. <sup>11</sup>	2004	2 University Affiliated Hospitals, United States	Medical ICU Patients (no trauma patients)	N/A	≤48 hours vs. 14-16 days	Clinician judgment	Early	60	60 (100)	31 (52)	63±10.4	APACHE II: 27.4±4.2
							Late	60	50 (83)	34 (57)	63±9.3	APACHE II: 26.3±2.6
Barquist et al. <sup>12</sup>	2006	University Affiliated Level 1 Trauma Centre, United States	Trauma Patients	N/A	<day 8 vs. > day 28	Certain inclusion criteria and clinician judgment	Early	29	27 (93)	20 (69)	53.7±21.5	APACHE II: 12.1±3.2
							Late	31	11 (35)	26 (84)	49.9±18.3	APACHE II: 13.1±5.1
Blot et al. <sup>5</sup>	2008	25 ICU's in France	Medical and Surgical ICU Patients (19% Trauma patients)	2002-2004	< day 4 vs. > day 14	Criteria based on previous work <sup>1, 21, 59, 65</sup> but application of these criteria up to treating clinician	Early	61	60 (98)	45 (74)	55 (19-88)#	SAPS II: 50 (17-103)#
							Late	62	16 (26)	43 (69)	58 (20-88)#	SAPS II: 50 (15-96)#
Terragni et al. <sup>13</sup>	2010	12 ICU's in Italy	Medical and Surgical ICU Patients (10% Trauma patients)	2004-2008	6-8 days vs. 13-15 days	Clinical parameters and clinician judgment	Early	209	145 (69)	138 (66)	61.8±17.4	SAPS II: 51.1±8.7
							Late	210	119 (57)	142 (68)	61.3±16.8	SAPS II: 49.7±8.6
Young et al. <sup>14</sup>	2013	72 ICU's in the United Kingdom	Medical and Surgical ICU Patients (including Cardiothoracic; unknown number trauma patients)	2004-2011	< 4 days vs. > 10 days	Clinician judgment	Early	451	420 (93)	263 (58)	63.6 ± 13.7	APACHE II: 19.6±6.5
							Late	448	204 (46)	264 (59)	64.2±13.3	APACHE II: 20.1±6.0
Bösel et al. <sup>15</sup>	2013	University Affiliated Hospital, Germany	Stroke/Spontaneous ICH Patients (no trauma patients)	2009-2011	≤ 3 days vs. 7-14 days	Non-validated in-house assessment score <sup>66</sup> and 2 clinicians' judgment	Early	30	30 (100)	20 (67)	61.0±12.0	APACHE II: 17 (13-19)#
							Late	30	18 (60)	20 (67)	61.0±13.0	APACHE II: 16 (11-19)#
Dunham et al. <sup>16</sup>	2014	University Affiliated Level 1 Trauma Centre, United States	Blunt Head Trauma Patients	N/A	3-5 days vs. 10-14 days	Clinician judgment	Early	17	17 (100)	N/A	33±13	ISS: 28±11
							Late	14	11 (79)	N/A	37±16	ISS: 35±9

\* - mean ± Standard deviation; # - median (interquartile range); ICU – Intensive Care Unite; N/A - not available; APACHE II – Acute Physiology and Chronic Health Evaluation II score; SAPS – Simplified Acute Physiology Score; ISS – Injury severity score

## **E2: Search Criteria**

### **Medline Search**

1. exp tracheostomy/
2. exp tracheotomy/
3. percutaneous tracheostomy.mp.
4. percutaneous tracheotomy.mp.
5. 1 or 2 or 3 or 4
6. exp Intensive Care Units/or exp Critical Care/or critical care medicine.mp.
7. exp Intensive Care Units/or exp Critical Care/or intensive care medicine.mp.
8. mechanical ventilation.mp or exp Respiration, Artificial/
9. prolonged ventilation.mp.
10. 6 or 7 or 8 or 9
11. 5 and 10
12. limit 11 to (English language and humans and yr="1960-2017" and "all adult (19 plus years)")

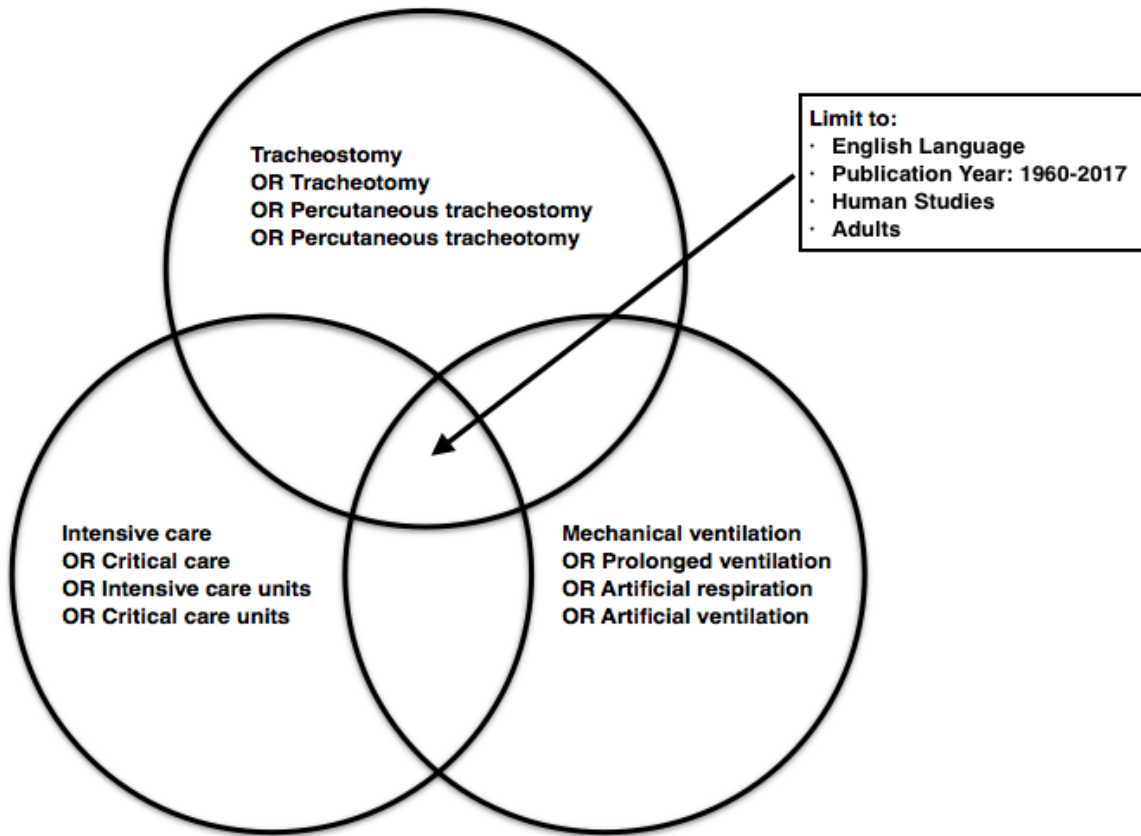
### **Embase Search**

1. exp tracheostomy/
2. exp tracheotomy
3. percutaneous tracheostomy.mp.
4. percutaneous tracheotomy.mp.
5. 1 or 2 or 3 or 4
6. exp intensive care/
7. critical care.mp.
8. prolonged ventilation.mp.
9. mechanical ventilation.mp. or exp artificial ventilation/
10. 6 or 7 or 8 or 9
11. 5 and 10
12. limit 11 to (human and English language and yr="1960 –2017" and adult <18 to 64 years>)

### **CENTRAL Evidence Based Medicine Reviews**

1. tracheostomy.mp
2. tracheotomy.mp
3. percutaneous tracheostomy.mp
4. percutaneous tracheotomy.mp
5. 1 or 2 or 3 or 4
6. intensive care.mp
7. critical care.mp
8. mechanical ventilation.mp
9. prolonged ventilation.mp
10. 6 or 7 or 8 or 9
11. 5 and 10
12. limit 11 to "all adult (19 plus years)"
13. limit 12 to English language
14. limit 13 to yr="1960-2017"
15. limit 14 to humans

**E3: Diagrammatic representation of the search strategy**



**E4: Risk of bias in each of the domains of the QUIPS tool described in text**

<b>Study</b>	<b>Study Participation</b>	<b>Study Attrition</b>	<b>Prognostic Factor Measurement</b>	<b>Outcome Measurement</b>	<b>Study Confounding</b>	<b>Statistical Analysis and Reporting</b>
<b>Kollef et al<sup>1</sup></b>	Low	Low	Low	Low	Moderate	Low
<b>Gurkin et al.<sup>27</sup></b>	Moderate	Moderate	Low	Low	Moderate	Low
<b>Padia et al.<sup>28</sup></b>	Low	Low	Low	Low	Moderate	Low
<b>Goettler et al.<sup>37</sup></b>	Moderate	Low	Moderate	Low	Moderate	Moderate
<b>Nathens et al.<sup>29</sup></b>	Low	Low	Low	Low	Low	Low
<b>Szeder et al.<sup>30</sup></b>	Moderate	Low	Low	Low	Moderate	Low
<b>Branco et al.<sup>31</sup></b>	Moderate	Low	Moderate	Low	Moderate	Low
<b>Shamim et al.<sup>32</sup></b>	Moderate	Moderate	Moderate	Low	Moderate	Low
<b>Huang et al.<sup>33</sup></b>	Low	Low	Moderate	Low	Moderate	Low
<b>Rampa et al.<sup>34</sup></b>	Low	Low	Low	Low	Low	Low
<b>Schönenberger et al.<sup>35</sup></b>	Low	Low	Moderate	Low	Low	Low
<b>Humble et al.<sup>36</sup></b>	Low	Low	Moderate	Low	Moderate	Moderate

**E5: Factors associated with tracheostomy by multivariate analysis for non brain injured patients**

<b>Study</b>	<b>Year published</b>	<b>Group</b>	<b>Risk of bias</b>	<b>Factors multivariate (logistic regression) analysis</b>	<b>Risk (OR or RR (95% CI))</b>	<b>Timing of factor</b>
<b>Kollef et al<sup>1</sup></b>	1999	All ICU patients	Intermediate	Nosocomial pneumonia	4.72 (3.24-6.87)	Varied
				Witnessed aspiration	3.79 (1.54-3.18)	Varied
				Receiving aerosol treatment	3.00 (2.18-4.13)	Varied
				Reintubation	2.21 (1.54-3.18)	Varied
<b>Padia et al.<sup>28</sup></b>	2003	Lung transplant recipients	Intermediate	Pneumonia	16.7 (3.6-78)	Varied
				Double lung transplant	12.4 (2.2-29)	Day 0
				Reintubation	5.7 (1.9-17.3)	Varied
				Cardiopulmonary bypass	5 (1.5-16.5)	Day 0

Day 0 = ICU admission

**E6: Factors associated with tracheostomy by univariate analysis.**

Study	Year published	Group	Factors Univariate analysis	OR (95% CI)
<b>Kollef et al<sup>1</sup></b>	1999	All ICU patients	Received aerosol therapy	24.79 (12.33-49.83)
			Developed VAP	6.21 (3.16-12.22)
			Witnessed aspiration	3.79 (1.59-9.02)
			Re-intubation	3.70 (1.94-7.05)
			Required fibre optic intubation	3.09 (1.26-7.61)
			Bone marrow organ-system derangement	2.38 (1.24-4.58)
			Lung organ system derangement	2.05 (1.14-3.7)
<b>Gurkin et al.<sup>27</sup></b>	2002	Head Injured Trauma Patients	Pneumonia	23.43 (6.93-79.28)
			ISS	20.8±9.5 vs. 30.5±8.6**
			GCS on presentation	9.7±4.3 vs. 6.5±4.0**
<b>Padia et al.<sup>28</sup></b>	2003	Lung transplant recipients	Pneumonia	16.66 (3.56-77.99)
			Double lung transplant	8.54 (2.27-32.06)
			Re-intubated	5.71 (1.88-17.38)
			Cardiopulmonary bypass	4.95 (1.49-16.47)
			Single lung transplant	0.08 (0.02-0.37)
<b>Goettler et al.<sup>37</sup></b>	2006	General trauma patients	N/A	
<b>Nathens et al.<sup>29</sup></b>	2006	General trauma patients	Spinal cord injury	RR 2.90 (1.95-2.26)
			ISS (cf. 9-15)	
			≥48	RR 2.28 (1.95-2.67)
			25-47	RR 2.19 (1.99-2.41)
		16-24	RR 1.62 (1.46-1.79)	

Maximum AIS score (cf. 3)	
6	RR 2.02 (1.51-2.36)
5	RR 1.56 (1.45-1.69)
4	RR 1.46 (1.35-1.56)
Co-morbidities	
Neurologic pre-existing disease (stroke/dementia)	RR 1.88 (1.75-2.02)
Coronary Artery disease	RR 1.67 (1.58-1.76)
Obesity	RR 1.46 (1.20-1.77)
Diabetes	RR 1.29 (1.15-1.46)
COPD	RR 1.20 (1.04-1.39)
None	RR 0.58 (0.55-0.61)
Rib fractures (cf. none)	
≥ 3	RR 1.61 (1.50-1.72)
1-2	RR 1.16 (1.04-1.29)
Age (cf.16-24 years)	
65-84	RR 1.46 (1.31-1.63)
56-64	RR 1.44 (1.27-1.62)
41-55	RR 1.29 (1.18-1.42)
Chest injury AIS ≥ 3	RR 1.43 (1.34-1.52)
Coma (cf. none)	
Prolonged	RR 1.23 (1.14-1.32)
Brief	RR 0.88 (0.82-0.95)
Hospital beds available (cf. lowest quartile (125-290)	
Third quartile (375-519)	RR 1.22 (1.06-1.41)
Highest quartile (520-908)	RR 1.18 (1.02-1.35)
University Teaching Hospital (cf. non teaching)	RR 1.21 (1.07-1.44)
Head injury AIS ≥3	RR 1.20 (1.14-1.28)



			ICU beds available (cf. lowest quartile (9-15))	
			Highest quartile (21-122)	RR 1.17 (1.08-1.27)
			Third quartile (21-30)	RR 1.12 (1.02-1.24)
			Trauma centre designation level (cf. level 1)	
			Level 3	RR 0.89 (0.81-0.96)
			Level 2	RR 0.87 (0.80-0.94)
			Penetrating trauma	RR 0.65 (0.59-0.72)
<b>Szeder et al.<sup>30</sup></b>	2010	Supratentorial intracranial haemorrhage	GCS on day 3 (Median < 11))	21.0 (2.3-242.3)
			Thalamic haemorrhage	11.0 (1.2-102.4)
			Hydrocephalus	8.4 (1.5-47.0)
			IVH grade (mean ± SD)	3.57±1.21 vs. 8.05±1.72**
			Pineal shift (mm) (mean ± SD)	0.78±0.37 vs. 2.33±0.64**
			Septum pellucidum shift (mm) (mean ± SD)	1.74±0.69 vs. 4.22±0.68**
<b>Branco et al.<sup>31</sup></b>	2011	Cervical spine Injury trauma patients	Intubated in ED	5.25 (4.43-6.23)
			ISS ≥ 16	4.39 (3.41-5.65)
			Complete C5-C7 level	2.98 (2.57-3.45)
			Intubated on Scene	2.95 (2.01-4.41)
			GCS ≤ 8 on admission	2.57 (2.20-3.01)
			Complete C1-C4 level	2.42 (2.00-2.92)
			Thoracic injury	1.84 (1.60-2.12)
			SBP < 90mmHg on admission	1.84 (1.53-2.22)
			Facial fracture	1.81 (1.48-2.21)
			RR < 10 or > 24 on admission	1.70 (1.44-2.01)
			Male	1.32 (1.12-1.55)
			Abdominal injury	1.31 (1.07-1.57)
			Pelvic/extremity injury	1.28 (1.09-1.49)

			Thoraco-lumbar fracture	1.19 (1.01-1.41)
			Age $\geq 55$	0.84 (0.72-0.98)
			Blunt trauma	0.62 (0.45-0.84)
			Incomplete C1-C4 level	0.59 (0.50-0.69)
			Incomplete C5-C7 level	0.44 (0.38-0.51)
<b>Shamim et al.</b> <sup>32</sup>	2011	Head Injured Trauma patients requiring decompressive craniectomy	Age (cf. 0-15)	
			>51	11.9*
			31-50	7.3*
			16-30	5.3*
			Co morbidities (cf. none)	
			$\geq 2$	3.7*
			1	1.3*
			Incident to arrival time (cf. 0-1.5hrs)	
			> 3 hours	4.2*
			1.5-3 hours	3.16*
			Arrival abnormal pupil response	3.4*
			Arrival GCS score (cf. 13-15)	
			3-4	0.57*
			5-8	0.25*
			9-12	0.08*
<b>Huang et al.</b> <sup>33</sup>	2013	Head Injured Trauma patients requiring decompressive craniectomy	Pupil reactivity at presentation	
			One or both not reacting	4.61 (2.11-10.09)
			Both reacting	0.22 (0.10-0.47)
			Interval from Head Injury to DC	
			$\leq 24$ hours	3.97 (1.14-13.84)

			> 24 hours	0.25 (0.07-0.88)
			Absent basal cisterns on CT brain	2.19 (1.01-4.75)
			Mean age (years) ( $\pm$ SD)	42 $\pm$ 20 vs. 52 $\pm$ 20**
			Mean head AIS ( $\pm$ SD)	5 $\pm$ 0 vs. 5 $\pm$ 0**
			Mean ISS ( $\pm$ SD)	26 $\pm$ 9 vs. 29 $\pm$ 7**
			Mean GCS at presentation ( $\pm$ SD)	9 $\pm$ 3 vs. 6 $\pm$ 3**
			Midline shift on CT (mm) (mean $\pm$ SD)	7 $\pm$ 5 vs. 10 $\pm$ 7**
<b>Rampa et al.</b> <sup>34</sup>	2015	In-hospital cardiac arrest patients with anoxic/hypoxic ischaemic encephalopathy	N/A	
<b>Schönenberger et al.</b> <sup>35</sup>	2016	Patients with ischaemic stroke, intracranial haemorrhage or subarachnoid haemorrhage	Ischaemic stroke	69.4% vs. 26.9% **
			Hemorrhagic stroke	30.6% vs. 73.1%
			SET score	6.9 $\pm$ 3.7 vs. 9.7 $\pm$ 3.2
<b>Humble et al.</b> <sup>36</sup>	2016	Trauma patients with severe traumatic brain injury	N/A	

\* 95% CI not provided; \*\* for non tracheostomy patients vs. tracheostomy patients; N/A - not available; VAP – Ventilator Associated Pneumonia; ISS – Injury Severity Score; GCS – Glasgow Coma Scale; AIS - Abbreviated Injury Scale; ICU – Intensive Care Unit; IVH – Intraventricular Haemorrhage; SBP – Systolic Blood Pressure; RR – Respiratory Rate; DC – Decompressive Craniectomy; CT – Computed Tomography; COPD – Chronic obstructive pulmonary disease; SET – Stroke related Early Tracheostomy

**E7: Tracheostomy risk factors in Goettler et al.<sup>37</sup>**

<b>100% Tracheostomy rate (3% of patients studied)</b>	<b>≥ 90% Tracheostomy Rate (10.6% of patients studied)</b>	<b>≥ 80% Tracheostomy Rate (25% patients studied)</b>
ISS = 75	ISS ≥ 54	ISS ≥ 38
ISS ≥ 50 & age ≥ 55	ISS ≥ 40 & age ≥ 40	Age ≥ 80
Admit/24 hr GCS = 3 & age ≥ 70	Admit/24 hr GCS = 3 & age ≥ 55	Admit/24 hr GCS = 3 & age ≥ 45
AIS abdomen, chest or extremities ≥ 5 and age ≥ 60	Paralysis (any level) & age ≥ 40	Damage control laparotomy & age ≥ 50
Bilateral pulmonary contusions & ≥ 8 rib fractures	Bilateral pulmonary contusions & age ≥ 55	Bilateral pulmonary contusions & age ≥ 50
Craniotomy and age ≥ 50		Aspiration & age ≥ 55
Craniotomy, ICP Monitor and age ≥ 40		Craniotomy & ICP monitor
Craniotomy & GCS ≤ 4 at 24 hours		Craniotomy & GCS ≤ 9 at 24 hours

ISS – Injury severity score; GCS – Glasgow Coma Scale; ICP – Intracranial Pressure

**E8: Details of Stroke related Early Tracheostomy Score in Schönenberger et al.<sup>35</sup>**

<b>Area of assessment</b>	<b>Situation</b>	<b>Points</b>
Neurological function	Dysphagia	4
	Observed aspiration	3
	GCS on admission < 10	3
Neurological Lesion	Brainstem	4
	Space-occupying cerebellar	3
	Ischaemic infarct > 2/3 MCA territory	4
	ICH volume > 25ml	4
	Diffuse lesion	3
	Hydrocephalus	4
	(Neuro)surgical intervention	2
General organ function/procedure	Additional respiratory disease	3
	PaO <sub>2</sub> /FiO <sub>2</sub> < 150	2
	APS (of APACHEII) > 20	4
	LIS > 1	2
	Sepsis	3

GCS – Glasgow coma scale; MCA – middle cerebral artery; ICH – intracerebral haemorrhage; PaO<sub>2</sub> – arterial partial pressure of oxygen; FiO<sub>2</sub> – fractional inspired oxygen; APS – acute physiology score; APACHEII – acute physiology and chronic health evaluation II; LIS – lung injury score.

**E9: Details of TRACH score in Szeder et al. <sup>30</sup>**

$$\text{TRACH Score} = 3 + (1 \times \text{RScale}) - (0.5 \times \text{GCS})$$

RScale = Radiological Scale

Radiological scale = sum of points of significant predictors: Location, Hydrocephalus, Septum Pellucidum shift (L + H + S)

- Location: Thalamus = 2 points; Other = 0 points
- Hydrocephalus: Present = 1.5 points; Absent = 0 points
- Septum Pellucidum shift: Present = 3 points; Absent = 0 points

All patients with a score < 0.7 were extubated and all patients with a score > 2.0 received a trachesotomy.

The TRACH Score had a reported ROC of 0.92, with a sensitivity to predict extubation of 94%, a specificity of 83%, a positive predictive value of 83% and a negative predictive value of 95%.