**Supplemental Digital Content**

**Timing of tracheostomy in acute traumatic spinal cord injury: a systematic review and meta-analysis**

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**Supplemental Appendix 1 – Search Strategy**

The following tables record the search strategies and terms used in each of the databases. Search results were limited to randomized and quasi-randomized controlled trials, case-control studies, and cohort studies, and include articles indexed from the inception of each of the databases to January 2020.

**Medline**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | spinal cord injur\*.mp. or traumatic spinal cord injur\*.mp. or spinal cord damage.mp. or traumatic injur\* or spinal cord.mp. or spinal cord compression.mp. or spinal trauma.mp. or SCI.mp. or ((spinal or "spinal cord") adj3 (contusion or laceration or transaction or ischemi\* or fracture\* or wound\* or trauma\* or injur\* or damag\*)).mp. or compression spinal cord.mp. or injured spinal cord.mp. or acute spinal cord injur\*.mp. or trauma spine.mp. or post-traumatic spinal cord injur\*.mp. or traumatic spine injur\*.mp. or trauma spinal cord.mp. or (myelopathy adj3 (traumatic or post-traumatic)).mp. or exp spinal cord injury/ or spinal cord.mp. or exp spinal cord ischemia/ or exp cervical vertebrae/ or (quadriplegi\* or tetraplegi\*).mp. or exp quadriplegia/ | 260752 | mp= multi-purpose fields (ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy) |
| 2 | tracheo?tom\*.af. or exp airway management/ or mechanical ventilation.mp. or exp respiration artificial/ or exp positive-pressure respiration/ | 145670 | af = All searchable fields  mp= multi-purpose fields (ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy) |
| 3 | (randomized controlled trial.pt. or randomized.mp. or placebo.mp.) or (random:.tw. or placebo:.mp. or double-blind:.tw) or exp cohort studies/ or (case$ and control$).tw. or cohort$.tw. or exp case-control studies/ or controlled clinical trial.pt. or epidemiologic methods/ or (prospective$ or retrospective$).tw. | 4127935 | Utilized the BMJ Best Practice study design search filters.  pt = publication type  tw = text word |
| 4 | 1 and 2 and 3 | 652 | Final results |

**EMBASE**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | spinal cord injur\*.mp. or traumatic spinal cord injur\*.mp. or spinal cord damage.mp. or traumatic injur\* spinal cord.mp. or spinal cord compression.mp. or spinal trauma.mp. or compression spinal cord.mp. or injured spinal cord.mp. or acute spinal cord injur\*.mp. or trauma spine.mp. or post-traumatic spinal cord injur\*.mp. or traumatic spine injur\*.mp. or trauma spinal cord.mp. or spinal cord.mp. or exp spinal cord ischemia/ or ((spinal or "spinal cord") adj3 (contusion or laceration or transaction or ischemi\* or fracture\* or wound\* or trauma\* or injur\* or damag\*)).ti,ab,kw. or ((spinal or "spinal cord") adj3 (contusion or laceration or transaction or ischemi\*)).ti,ab,kw. or exp cervical vertebrae/ or exp quadriplegia/ or SCI.ti,ab,kw. or (quadriplegi\* or tetraplegi\*).ti,ab,kw. or (myelopathy adj3 (traumatic or post-traumatic)).ti,ab,kw. or ((spinal or "spinal cord") adj3 (fracture\* or wound\* or trauma\* or injur\* or damag\*)).ti,ab,kw. | 320311 | mp= multi-purpose fields (ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy)  Title (TI), Abstract (AB), Original Title (OT), Name of Substance Word (NM), Subject Heading Word (HW), Floating Sub-Heading Word (FX), Keyword Heading Word (KF), Organism Supplementary Concept Word (OX), Protocol Supplementary Concept Word (PX), Rare Disease Supplementary Concept Word (RX), Unique Identifier (UI), Synonyms (SY)  ti,ab,kw = terms in either title or abstract or keyword fields |
| 2 | exp airway management/ or tracheo?tom\*.af. or exp artificial ventilation/ or mechanical ventilation.mp. | 247644 | af = All searchable fields  mp= multi-purpose fields (ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy) |
| 3 | epidemiologic methods/ or exp case-control studies/ or (case$ and control$).tw. or exp cohort analysis/ or exp longitudinal study/ or exp prospective study/ or exp follow up/ or exp case study/ or cohort$.tw. or (placebo:.mp. or double-blind:.tw. or randomized controlled trial.pt. or random\*.mp.) | 5161968 | Utilized the BMJ Best Practice study design search filters.  mp= multi-purpose fields (ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy)  tw = text word  pt = publication type |
| 4 | 1 and 2 and 3 | 936 | Final results |

**CENTRAL**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | MeSH descriptor: [Spinal Cord Injuries] explode all trees or (spinal cord injur\*).mp. (Word variations have been searched) or (trauma spin\* cord).mp. (Word variations have been searched) or MeSH descriptor: [Spinal Cord] explode all trees or (spin\* trauma) (Word variations have been searched) or (spinal cord).mp. (Word variations have been searched) or MeSH descriptor: [Spinal Cord Ischemia] explode all trees or ((spinal or "spinal cord") near/3 (contusion or laceration or transaction or ischemi\* or fracture\* or wound\* or trauma\* or injur\* or damag\*)).mp. (Word variations have been searched) or MeSH descriptor: [Cervical Vertebrae] explode all trees or MeSH descriptor: [Quadriplegia] explode all trees or (SCI):ti,ab,kw (Word variations have been searched) or (quadriplegi\* or tetraplegi\*).mp. (Word variations have been searched) | 22067 | mp = defaults to the following ‘multi-purpose’ (.mp.) fields for this database: ti,ab,ot,nm,hw,fx,kf,ox,px,rx,ui,sy.  Title (TI), Abstract (AB), Original Title (OT), Name of Substance Word (NM), Subject Heading Word (HW), Floating Sub-Heading Word (FX), Keyword Heading Word (KF), Organism Supplementary Concept Word (OX), Protocol Supplementary Concept Word (PX), Rare Disease Supplementary Concept Word (RX), Unique Identifier (UI), Synonyms (SY)  ti,ab,kw = terms in either title or abstract or keyword fields |
| 2 | tracheo?tom\* (Word variations have been searched) or MeSH descriptor: [Tracheostomy] explode all trees or MeSH descriptor: [Respiration, Artificial] explode all trees or (mechanical ventilation):ti,ab,kw (Word variations have been searched) or (airway management):ti,ab,kw in Trials (Word variations have been searched) | 17904 | ti,ab,kw = terms in either title or abstract or keyword fields |
| 3 | 1 and 2 | 404 | Final results |

**Web of Science**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | TS=(spinal cord injur\* OR spinal cord damage OR traumatic spinal cord injur\* OR spinal cord compression OR spinal trauma OR acute spinal cord injur\* OR trauma spine OR post-traumatic spinal cord injur\* OR traumatic spin\* injur\* OR trauma spinal cord OR spinal cord OR SCI OR ((spinal or “spinal cord”) near/3 (contusion or laceration or transaction or ischemi\* or fracture\* or wound\* or trauma\* or injur\* or damage\*)) OR (myelopathy near /3 (traumatic or post-traumatic)) OR spinal cord ischemi\* OR cervical vertebrae OR (quadriplegi\* or tetraplegi\*) | 280,077 | Search TS for topic terms in the title, abstract, author keywords, and Keywords Plus ®  Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI Timespan=All years |
| 2 | TS=(airway management OR mechanical ventilation OR artificial respiration OR positive-pressure respiration OR tracheo$tom\*) | 89,027 | Search TS for topic terms in the title, abstract, author keywords, and Keywords Plus ®  Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI Timespan=All years |
| 3 | TS=(random\* or clinical trial\* or “health care quality” or “healthcare quality”) OR ((cohort stud\*) or (case-control stud\*)) | 2, 760,494 | Search TS for topic terms in the title, abstract, author keywords, and Keywords Plus ®  Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI Timespan=All years |
| 4 | 1 and 2 and 3 | 204 | Final results |

SCI-EXPANDED = Science Citation Index

SSCI = Social Sciences Citation Index

A&HCI = Arts & Humanities Citation Index

CPCI-S = Conference Proceedings Citation Index- Science

CPCI-SSH = Conference Proceedings Citation Index- Social Science & Humanities

BKCI-S = Book Citation Index- Science

BKCI-SSH = Book Citation Index- Social Science & Humanities

ESCI = Emerging Sources Citation Index

**CINAHL**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | TX spinal cord injur\* OR AB ((myelopathy N3 (traumatic or post- traumatic))) OR TI ((myelopathy N3 (traumatic or post- traumatic))) AB (((spinal or spinal) N3 (fracture\* or wound\* or trauma\* or injur\* or damag\*))) or TI (((spinal or spinal) N3 (fracture\* or wound\* or trauma\* or injur\* or damag\*))) OR AB (((spinal cord N3 (contusion or laceration or transaction or trauma or ischemia))) OR TI (((spinal cord N3 (contusion or laceration or transaction or trauma or ischemia))) OR AB (SCI) OR TI (SCI) OR (MH “cervical vertebrae/IN”) or (MH “quadriplegia”) OR AB (((quadriplegi\* or tetraplegi\*))) OR TI (((quadriplegi\* or tetraplegi\*))) OR (MH "spinal cord injuries+") OR (MH "spinal injuries+") OR (MH "spinal cord+") OR (MH "spinal cord compression") OR (MH "spinal cord ischemia+") | 52,993 | TX = all text (will search full text available within the CINAHL database)  AB = abstract  TI = title  MH = MeSH terms |
| 2 | (MH "respiration, artificial+") OR (MH "ventilator weaning") OR (MH "ventilation, manual") (MH "respiration, artificial+") OR (MH "ventilator weaning") OR (MH "ventilation, manual") OR TX mechanical ventilation OR TX tracheo#tom\* | 50,384 | TX = all text (will search full text available within the CINAHL database)  MH = MeSH terms |
| 3 | TX randomized control\* trial\* OR TX clinical trial\* OR TX cohort stud\* OR TX case-control stud\* | 647,636 | TX = all text (will search full text available within the CINAHL database) |
| 4 | S1 AND S2 AND S3 | 458 | Final results |

**SCOPUS**

|  |  |  |  |
| --- | --- | --- | --- |
| Set | History | Results | Comments |
| 1 | (spinal AND cord AND damage)) OR  ( spin\*  AND cord  AND injur\* ) OR  ( spinal  AND cord  AND compression )   OR  ( traumatic  AND injur\*  AND spinal  AND cord )   OR   ( spin\*  AND traum\* )  OR  ( injur\*  AND spinal  AND cord )   OR  ( acute  AND spinal  AND cord  AND injur\* ) )  OR ( post traumatic  AND spinal  AND cord  AND injur\* ) | 135,417 | Search  TITLE-ABS-KEY for terms in the title, abstract, or keywords |
| 2 | (tracheo\*tom\* ) OR ( artificial AND respiration ) OR ( airway AND management ) OR ( airway AND extubation ) OR ( high-frequency AND ventilation ) OR ( interactive AND ventilatory AND support ) OR ( liquid AND ventilation ) OR ( noninvasive AND ventilation ) OR ( positive-pressure AND respiration ) OR ( continuous AND positive AND airway AND pressure ) OR ( airway AND extubation ) OR ( intermittent AND positive-pressure AND breathing ) OR ( intermittent AND positive-pressure AND ventilation ) OR ( ventilator AND weaning ) OR ( intratracheal AND intubation ) OR ( laryngeal AND mask ) | 177,455 | Search  TITLE-ABS-KEY for terms in the title, abstract, or keywords |
| 3 | (clinical AND trial\* OR trial\* OR rct\* OR random\* OR blind\* ) OR ( cohort AND stud\* ) OR ( case-control AND stud\* ) | 2,951,358 | Search  TITLE-ABS-KEY for terms in the title, abstract, or keywords |
| 4 | 1 and 2 and 3 | 312 | Final results |

**Google Scholar**

|  |  |
| --- | --- |
| 1 | (tracheo$tom\* OR intubat\* OR "mechanical ventilation" OR "artificial respiration" OR "airway management") AND ("spinal cord injury\*" OR "trauma\* spine\*" or "spinal cord compression") |
| 2 | (tracheostomy OR intubated\*) AND ("spinal cord injury" OR "spin\* trauma" or "spinal cord compression") |
| 3 | Timing tracheostomy spinal cord |

**Conference proceedings**

American Association of Neurological Surgeons, American Academy of Neurology, American Neurology Association, American Society of Anesthesiologists, Asian Society for Neuroanesthesia and Critical Care, Australian Society of Anesthesiologists, Canadian Neurological Sciences Federation, Congress of Neurological Surgeons, Canadian Spine Society, European Federation of Neurological Societies, European Association of Neurosurgical Societies, EUROSPINE, International Anesthesia Research Society, Japanese Society of Neuroanesthesia and Critical Care, Neurocritical Care Society, North American Spine Society, Society for Neuroscience in Anesthesiology and Critical Care, Society of Critical Care Medicine, World Congress of Neurology, World Federation of Neurosurgical Societies, World Federation of Societies of Anaesthesiologists, and World Federation of Societies of Intensive and Critical Care Medicine.

**Supplemental Appendix 2 – Sensitivity Analysis of Database Search**

|  |  |
| --- | --- |
| **Study** | Identified in Search |
| Galeiras 2018 [1] | Yes - Medline |
| Romero 2009 [2] | Yes - Medline |
| Flanagan 2018 [3] | Yes - Medline |
| Wang 2018 [4] | Yes - Medline |
| Jones 2015 [5] | Yes - Medline |
| Richard-Denis 2018 [6] | Yes - Medline |
| Berney 2011 [7] | Yes - Medline |
| Romero-Ganuza 2011 [8] | Yes - Medline |
| O’Keefe 2004 [9] | Yes - Medline |
| Wilson 2019 [10] | No |

**Supplemental Appendix 3 – Data Extraction Sheet**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** |  | | | | | | | | | | | |
| Year of publication |  | | | | | | | | | | | |
| Country |  | | | | | | | | | | | |
| Journal of publication |  | | | | | | | | | | | |
| Reviewer |  | | | | | | | | | | | |
| Author (last name) |  | | | | | | | | | | | |
| Author’s contact details: | | | | | | | | | | | | |
| Author(s) contacted (if yes, specify reason): | | | | | | | | | | | | |
| Multi-Centre |  | | | | Single Centre | | |  | | | | |
| **PARTICIPANTS (SCI= spinal cord injury)**  Inclusion criteria: Patients admitted to the ICU with acute traumatic SCI at the cervical or high thoracic level (irrespective of severity (ASIA), co-morbidities, or mechanism of injury) requiring mechanical ventilation. | | | | | | | | | | | | |
| ICU setting/ patient population |  | | | | | | | | | | | |
| SCI characteristics | ASIA score in either group:  Level of injury included: | | | | | | | | | | | |
| N (%) | Total acute SCI | | | |  | Early |  | | | | Late |  |
| Age Mean (SD) | Total acute SCI | | | |  | Early |  | | | | Late |  |
| Female gender N (%) | Total acute SCI | | | |  | Early |  | | | | Late |  |
| Type of tracheostomy n/N (%) | Percutaneous | | | |  | | Surgical | | | |  | |
| Any statistical differences at baseline between groups? |  | | | | | | | | | | | |
| **INTERVENTIONS** | | | | | | | | | | | | |
| **Early tracheostomy timing**  (state whether day 0 or 1= intubation or ICU admission) | |  | | | | | | | | | | |
| **Actual time of trach placement in Early**  Mean (SD)/Median (IQR) | |  | | | | | | | | | | |
| **Late tracheostomy timing**  (state whether day 0 or 1= intubation or ICU admission) | |  | | | | | | | | | | |
| **Actual time of trach placement in Late**  Mean (SD)/Median (IQR) | |  | | | | | | | | | | |
| **OUTCOMES** | | | | | | | | | | | | |
| **Primary outcome** | | | | | | | | | | | | |
| **Short-term mortality** | | | **Early** N (%) (% of total SCI) | | | | | | **Late** N (%) (% of total SCI) | | | |
|  | | |  | | | | | |  | | | |
| Number of patients providing relevant data | | |  | | | | | |  | | | |
| Timing:  ICU mortality  Hospital mortality | | | *(Tick below)*  **□**  **□** | | | | | | | | | |
| **Secondary outcomes** | | | | | | | | | | | | |
| **1. Long-term mortality** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| Timing:  Hospital discharge  6 months  1 year  Other\_\_\_\_\_\_\_\_\_ | | | | *(Tick below)*  **□**  **□**  **□**  **□** | | | | | | | | |
| **2. Duration of MV (days)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **3. Actual number of patients receiving tracheostomy** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **4. Duration of Sedation (days)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **5. Length of stay in ICU (days)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **6. Length of stay in Hospital (days)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **7. Ventilator-associated pneumonia at any time point** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **8. Total tracheostomy complications** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **9. Tracheostomy bleeding at any time point** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **10. Laryngotracheal injury at any time point**  (Epiglottis, vocal cords, larynx, subglottic ulceration, inflammation) | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **11. Surgical Wound Infection** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **12. ICU-associated complications (DVT, PE, decubitus ulcers)** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **13. Time to extubation/decannulation** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **14. Time to swallowing (with ability to eat an oral diet)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **15. Time to speaking (either via a speaking valve or translaryngeal)** | | | | **Early** Mean (SD) | | | | | | **Late** Mean (SD) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **16. Long-term benefits** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |
| **17.** **Extubation failure** | | | | **Early** N (%) | | | | | | **Late** N (%) | | |
|  | | | |  | | | | | |  | | |
| Number of patients providing relevant data | | | |  | | | | | |  | | |

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| --- |
| **Notes**  Provide info on standardized pneumonia diagnostic criteria presented in the paper: |

**Supplemental Appendix 4 – Data Quality Analysis**

The NOS was utilized to assess the quality of the studies, with scores converted to the Agency for Healthcare Research and Quality (AHRQ) standards. The NOS can be customized to the review question of interest and uses a ‘star system’ to assign up to 9 points for each study based on the selection, comparability, and outcomes of their cohorts. A higher number of points indicates a lower risk of bias. The selection, comparability, and outcome/exposure domains can be awarded a maximum of 4 stars, 2 stars and 3 stars, respectively (for a total score of 9 points). To be reported as good quality a study must receive 3 or 4 stars in the selection domain, 1 or 2 stars in the comparability domain, and 2 or 3 stars in the outcome/exposure domain. Fair quality consists of 2 stars in the selection domain, 1 or 2 stars in the comparability domain, and 2 or 3 stars in the outcome/exposure domain. Finally, poor quality consists of 0 or 1 star in the selection domain, or 0 stars in the comparability domain, or 0 or 1 stars in outcome/exposure domain. In this review, 12 studies were assessed as being good quality, 4 were poor quality, and 1 was unable to be assessed (Table 2 and Table 3). All 4 studies assessed as poor quality received 0 stars in the comparability domain, and one of these studies also performed poorly in the selection domain, receiving 1 star.

|  |  |  |
| --- | --- | --- |
| **Selection** (tick one box in each section) | | |
| 1. Representativeness of the intervention cohorta) Truly representative of the SCI populationb) Somewhat representative of the SCI populationc) Selected group of patientsd) No description of the derivation of the cohort | **\***  **\*** | 🞏  🞏  🞏  🞏 |
| 2. Selection of the non-intervention cohorta) Drawn from the same community as the intervention cohortb) Drawn from a different sourcec) No description of the derivation of the non-intervention cohort | **\*** | 🞏  🞏  🞏 |
| 3. Ascertainment of interventiona) Secure record (e.g. health care record)b) Structured interviewc) Written self-reportd) Other / no description | **\***  **\*** | 🞏  🞏  🞏  🞏 |
| 4. Demonstration that the outcome of interest was not present at the start of the study  1. Yes 2. No | **\*** | 🞏  🞏 |
| **Comparability** (tick up to two boxes, as appropriate) |  |  |
| 1. Comparability of cohorts on the basis of the design or analysisStudy controls for ageStudy controls for GCS motor or total scoreStudy controls for level of injuryStudy controls for any additional factors (e.g. CT characteristics)  1. Inadequate degree of control | **\***  **\***  **\***  **\*** | 🞏  🞏  🞏  🞏  🞏 |
| **Outcome** (tick one box in each section) |  |  |
| 1. Assessment of outcomea) Independent blind assessmentb) Record linkagec) Self report d) Other / no description | **\***  **\*** | 🞏  🞏  🞏  🞏 |
| 2. Was follow up long enough for outcomes to occura) Yes, if median duration of follow-up >= 6 monthb) No, if median duration of follow-up < 6 months | **\*** | 🞏  🞏 |
| 3. Adequacy of follow up of cohortsa) Complete follow up: all subjects accounted forb) Subjects lost to follow up unlikely to introduce bias: number lost <= 20%,  or description of those lost suggesting no different from those followedc) Follow up rate < 80% (select an adequate %) and no description of those lostd) No statement | **\***  **\*** | 🞏  🞏  🞏  🞏 |

|  |
| --- |
| **NEWCASTLE - OTTAWA QUALITY ASSESSMENT COHORT STUDIES**  (Assessment made for primary outcome of analysis)  Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability. |

**TOTAL SCORE: /9**

|  |  |  |
| --- | --- | --- |
| **Selection** (tick one box in each section) | | |
| 1. Is the case definition adequate?  a) yes, with independent validation  b) yes, e.g. record linkage or based on self-reports  c) no description | **\*** | 🞏  🞏  🞏 |
| 2. Representativeness of the cases  a) consecutive or obviously representative series of cases  b) potential for selection biases or not stated | **\*** | 🞏  🞏 |
| 3. Selection of Controls  a) community controls  b) hospital controls  c) no description | **\*** | 🞏  🞏  🞏 |
| 4. Definition of Controls  a) no history of disease (endpoint)  b) no description of source | **\*** | 🞏  🞏 |
| **Comparability** (tick one or both boxes, as appropriate) |  |  |
| 1. Comparability of cases and controls on the basis of the design or analysisStudy controls for level of SCIStudy controls for any additional factors (e.g. ASIA score, age) | **\***  **\*** | 🞏  🞏 |
| **Exposure** (tick one box in each section) |  |  |
| 1. Ascertainment of exposure  a) secure record (e.g. surgical records)  b) structured interview where blind to case/control status  c) interview not blinded to case/control status  d) written self-report or medical record only  e) no description | **\***  **\*** | 🞏  🞏  🞏  🞏  🞏 |
| 2. Same method of ascertainment for cases and controls  a) yes  b) no | **\*** | 🞏  🞏 |
| 3. Non-Response rate  a) same rate for both groups  b) non-respondents described  c) rate different and no designation | **\*** | 🞏  🞏  🞏 |

|  |
| --- |
| **NEWCASTLE - OTTAWA QUALITY ASSESSMENT CASE SERIES**  (Assessment made for primary outcome of analysis)  Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability. |

**TOTAL SCORE: /9**

**NOS – CODING MANUAL FOR COHORT STUDIES**

***SELECTION***

1. **Representativeness of the Exposed Cohort (NB exposure = intervention)**

Item is assessing the representativeness of exposed individuals in the community, not the representativeness of the study sample from some general population. For example, subjects derived from groups likely to contain exposed people are likely to be representative of exposed individuals, while they are not representative of all people the community.

*Allocation of stars as per rating sheet*

1. **Selection of the Non-Exposed Cohort**

*Allocation of stars as per rating sheet*

1. **Ascertainment of Exposure**

*Allocation of stars as per rating sheet*

1. **Demonstration That Outcome of Interest Was Not Present at Start of Study**

In the case of mortality studies, outcome of interest is still the presence of a disease/ incident, rather than death. That is to say that a statement of no history of disease or incident earns a star.

***COMPARABILITY***

1. **Comparability of Cohorts on the Basis of the Design or Analysis**

Either exposed and non-exposed individuals must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the relative risk for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

*A maximum of 2 stars can be allotted in this category.*

***OUTCOME***

1. **Assessment of Outcome**

For some outcomes, reference to the medical record is sufficient to satisfy the requirement for confirmation. This may not be adequate for other outcomes where reference to specific tests or measures would be required.

1. Independent or blind assessment stated in the paper, or confirmation of the outcome by reference to secure records (health records, etc.)
2. Record linkage (e.g. identified through ICD codes on database records)
3. Self-report (i.e. no reference to original health records or documented source to confirm the outcome)
4. No description
5. Other
6. **Was Follow-Up Long Enough for Outcomes to Occur**

An acceptable length of time should be decided before quality assessment begins.

1. **Adequacy of Follow Up of Cohorts**

This item assesses the follow-up of the exposed and non-exposed cohorts to ensure that losses are not related to either the exposure or the outcome.

*Allocation of stars as per rating sheet*

**Supplemental Appendix 5 – Definitions of Outcome Measures**

|  |  |
| --- | --- |
| **Outcome** | **Definition** |
| Long-term mortality | Long-term mortality is defined as deaths reported at either hospital discharge, 6 months or 1-2 years following the acute illness (i.e. furthest possible time-point out from admission to hospital) |
| Ventilator-Associated Pneumonia | Pneumonia is defined by clinical (fever or hypothermia, purulent tracheal secretions), laboratory (leukocytosis or leukopenia), and imaging (new and persistent infiltrate on chest X-ray) findings attributed by the authors of the individual trials to this infection. |
| Total Tracheostomy-Related Complications | It refers to both intraoperative (bleeding, tube dislocation, hypoxemia, arrhythmia and cardiac arrest) and postoperative (bleeding, stoma infection, stoma inflammation, pneumothorax, subcutaneous emphysema, airway stenosis, tracheal granuloma, tracheoesophageal fistula, mediastinal abscess, cannula displacement) complications.  Not all the initially included patients in each trial were analyzed for this outcome; only those who actually underwent tracheostomy. For trials which did not report on the number of patients who actually underwent tracheostomy, we considered that all included patients were tracheostomized. |
| Tracheostomy-Related Bleeding | It refers to both minor (i.e. not requiring blood transfusion) and major (i.e. requiring transfusion of at least 1 unit of packed red cells). Also, it refers to both intraoperative and postoperative bleeding. Not all the initially included patients in each trial were analyzed for this outcome; only those who actually underwent tracheostomy. For trials which did not report on the number of patients who actually underwent tracheostomy, we considered that all included patients were tracheostomized. |
| Duration of Mechanical Ventilation | It refers to total duration of mechanical ventilation, i.e. both before and after tracheostomy. |
| Surgical tracheostomy | Tracheostomy performed by surgeons in the operating theatre using an open technique. |
| Percutaneous tracheostomy | Usually a tracheostomy based on: 1) needle-guide wire airway access followed by serial dilations with sequentially larger dilators; 2) guide wire dilating forceps; 3) mini tracheostomy only for emergency airway access or for aspiration of retained bronchopulmonary secretions. |
| Long term benefits | Includes quality of life measures including Life Satisfaction Index and Beck Depression Inventory. |
| Extubation failure | Refers to the need for reintubation following extubation, as well as associated consequences (pneumonia, hypoxia, and cardiac arrest). |

**Supplemental Appendix 6 – Summary of ‘Timing’ Definitions**

|  |  |  |
| --- | --- | --- |
| **Study** | **Time of Early Tracheostomy** | **Time of Late Tracheostomy** |
| **Babu**  **2013** | ≤6 days from ACSF | 7-12 from ACSF |
| **Bellamy 1973** | < 3 days from injury | > 3 days from injury |
| **Beom 2018** | <7 days from surgery  Mean: 3.8 days | >7 days from surgery  Mean: 10.7 days |
| **Choi**  **2013** | <10 days from intubation  Mean: 6.7 (3.97) days | >10 days from intubation  Mean: 24 (5.66) days |
| **Flanagan 2018** | <7 days from intubation | >7 days from intubation |
| **Galeiras 2018** | Before cervical surgery or <4 days from surgery  Days between onset of lesion and tracheostomy procedure (mean (SD)): 10.2 (7.3) | >4 days from surgery  Days between onset of lesion and tracheostomy procedure (mean (SD)): 20.0 (11.7) |
| **Ganuza 2011** | <7 days from orotracheal intubation | ≥7 days from orotracheal intubation |
| **Guirgis 2016** | <7 days from injury | >7 days from injury |
| **Holscher 2014** | <7 days from injury  Mean: 4 (3-4) (95% confidence interval) | >7 days from injury  Mean: 15 (13-17) (95% confidence interval) |
| **Jeon 2014** | <10 days from MV  Mean: 6.8 (2.0) | >10 days from MV  Mean: 13.6 (4.8) |
| **Khan 2020** | <7 days from injury | >7 days after injury |
| **Kornblith 2013** | <7 days (starting timepoint not defined) | >7 days (starting timepoint not defined) |
| **Leelapattana**  **2012** | ‘Early’ and ‘late’ tracheostomy were not defined in this study, however the authors examined whether correlations existed between both duration of MV and hospital LOS with the time from injury to tracheostomy (which was plotted as a range from 0-60 days). | |
| **Lozano 2018** | <4 days from ACF  2.4 (mean # days after ACF)  2.8 (mean # days after injury) | >4 days from ACF  9.7 (mean # days after ACF)  11.1 (mean # days after injury) |
| **Romero 2009** | <7 days from intubation | >7 days from intubation |
| **Vitaz 2001** | Mean/median not reported, but patients in the Clinical Pathway group requiring mechanical ventilation underwent tracheostomy on approximately day 4 post-injury | NR |
| **Wu, 2013\*** | NR | NR |

ACSF, anterior cervical spine fixation; MV, mechanical ventilation; SD, standard deviation; ACF, anterior cervical fusion; NR, not reported

**Supplemental Appendix 7 – Patient Characteristics of Included Studies**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Type of T,**  **N (%)** | **Age in years,**  **mean (SD) or median (IQR)** | | **Female, (%)** | | **Disease severity,**  **mean (SD) or median (IQR)** | |
| **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** |
| **Babu**  **2013** | PT, 4 (20%)  ST, 16 (80%) | Median age (range): 47 (22-86) | | 2 (10%) | | GCS: 12.2 (4.2)  ISS (median): 6  ASIA: 55% category A, 0% category B, 15% category C, 15% category D, 5% category E | |
| **Bellamy 1973** | NR | Range: 3-78 years old | | 10/54 (18.5%) | | NR | NR |
| **Beom 2018** | NR | 51.2 | 58.9 | 2/10 (20%) | 1/12 (8.33%) | ASIA: 7.7 | ASIA: 19.5 |
| **Choi 2013** | ST, 21 (100%) | 54.4 (14.1) | 45.6 (16.5) | 1/10 (10%) | 1/11 (9%) | ASIA: 20% category A, 20% category B, 60% category C | ASIA: 54.5% category A, 9.1% category B, 27.3% category C, 9.1% category D |
| **Flanagan 2018** | NR | 52.1 | 48.8 | 17 (24.3%) | | ISS: 19.5  GCS: 10.1  AIS: 3.7 | ISS:19.7  GCS: 12.1  AIS: 3.2 |
| **Galeiras 2018** | ST, 9 (16.1%)  PT, 47 (83.9%) | 49.9 (20.8) | 48.3 (19.7) | 7/31 (22.6%) | 1/25 (4%) | APACHE II: 11.7(7.6)  GCS: 13.5 (3.4)  ISS Score: 27.1 (13.0) | APACHE II: 11.4 (5.7)  GCS: 13.6 (2.8)  ISS Score: 26.3 (11.4) |
| **Ganuza 2011** | ST, 118 (55%)  PT, 97 (45%) | 39.2 (8.9) | 43.7 (9.2) | 20/101 (19.8%) | 23/114 (20.2%) | APACHE II: 6.86 (4.11)  ASIA: 83.2% A+B, 16.8% C+D | APACHE II: 8.04 (5.3)  ASIA: 91.2% A+B, 8.8% C+D |
| **Guirgis 2016** | PT, 69 (100%) | High SCI: 31.7 (8.3)  Low SCI: 32.7 (7.8) | High SCI: 35.9 (9.2)  Low SCI: 35.8 (7) | High SCI: 8/32 (25%)  Low SCI: 3/19 (15.8%) | High SCI: 3/13 (23.1%)  Low SCI: 1/5 (20%) | High SCI ISS: 23 (71.9)  Low SCI ISS: 11 (57.9) | High SCI ISS: 6 (46.2)  Low SCI ISS: 4 (80) |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Holscher 2014** | ST, 37 (41%)  PT, 54 (59%) | 14 (13-16) | 13 (11-14) | 14/43 (33%) | 10/48 (41%) | ISS: 34 (29-39) | ISS: 36 (32-40) |
| **Jeon 2014** | ST, 125 (100%) | 59 (16) | 59 (15) | 19/39 (48.7%) | 37/86 (43.0%) | APACHE II: 23.1 (5.7)  GCS on ICU admission: 5.8 (3.1) | APACHE II: 22.2 (5.5)  GCS on ICU admission: 5.5 (3.1) |
| **Khan 2020** | NR | 42.3 (13) | 49.4 (11) | 75/280 (27%) | 210/859 (24%) | Cervical-spine AIS: 4 (4-5)  ISS: 19 (15-29) | Cervical-spine AIS: 4 (3-5)  ISS: 17 (11-28) |
| **Kornblith 2013** | NR | 43 (18-82) | 44 (18-82) | 8/57 (14%) | 16/61 (26.2%) | Median arrival GCS:12 (3-15) | Median arrival GCS:14 (5-15) |
| **Leelapattana**  **2012** | NR | 34.7 (16) | PI  40.6 (19.4) | 9/41 (22%) | PI  6/25 (24%) | ISS: 35.4 (9.7)  GCS: 10.2 (4.6) | PI  ISS: 32.8 (16.1)  GCS: 11.1 (4.7) |
| **Lozano 2018** | ST, 18 (18.4%)  PT, 77 (78.6%) | 50.2 (25.8-74.6) | 51.8 (29-74.6) | 10/39 (25.6%) | 14/59 (23.7%) | Median ISS: 26.00 (25-34)  Median admit GCS: 14 (3-15)  ASIA: 6 (15.4) no SCI, 6 (15.4) B,C,D, 27 (69.2) A | Median ISS: 26.00 (18-30)  Median admit GCS: 15 (10-15)  ASIA:8 (13.6) no SCI, 16 (27.1) B,C,D, 35 (59.3) A |
| **Romero 2009** | ST, 83 (55%)  PT, 69 (45%) | 38.06 (1.87) | 43.66 (1.85) | 14/71(19.7%) | 16/81 (19.8%) | APACHE: 6.86 (0.4)  ISS: 28.47 (0.87)  ASIA: 55 (77.5%) A, 4 B (5.6%), 11 (15.5%) C, 1 (1.4%) D | APACHE: 8.04 (0.63)  ISS: 29.99 (0.80)  ASIA: 64 (79%) A, 10 (12.4%) B, 7 (8.6%) C |
| **Vitaz 2001** | NR | 33 (15) | 34 (10) | NR | NR | ASIA motor score: 22 (22)  ISS: 25 (7) | ASIA motor score: 19 (24)  ISS: 25 (9) |
| **Wu 2013** | NR | NR | NR | NR | NR | NR | NR |

N, number of patients; T, tracheostomy; ET, early tracheostomy; LT, late tracheostomy; PI, prolonged intubation; NR, not reported; NA, non-applicable; MV, mechanical ventilation; ICU, intensive care unit; LOS, length of stay; SD, standard deviation; IQR, interquartile range

**Supplemental Appendix 8 – Summary of Results**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Actual number that received T, n/N (%)** | | **Short-term mortality, n (%)** | | **ICU mortality,**  **n (%)** | | **Hospital mortality,**  **n (%)** | | **Long-term mortality, n (%)** | | | **Ventilator- associated pneumonia,**  **n (%)** | | **Duration of MV, mean days (SD)** | | | **Duration of sedation, mean days (SD)** | | **Hospital LOS, mean days (SD)** | | **ICU LOS, mean days (SD)** | | **Laryngotracheal complications,**  **n (%)** | |
| **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** | | **ET** | **LT/PI** | **ET** | **LT/PI** | | **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** | **ET** | **LT/PI** |
| **Babu 2013[[1]](#endnote-1)** | 9/9  (100%) | 9/9  (100%) | 2/20 (10%) patients died during **initial hospital stay** (unrelated to ACSF or tracheostomy placement) | | NR | NR | NR | NR | | 7/20 (35%)[[2]](#endnote-2) | | 10/20 (50%) of patients developed VAP (9/10 prior to trach, 1/10 following trach) | | | NR | NR | NR | NR | 26.7 (15 | 49 (37.4) | NR | NR | NR | NR |
| **Bellamy 1973** | Complete quadriplegia: 23/23  Incomplete quadriplegia: 8/8  \*One patient underwent 2 tracheostomies | | NR | NR | NR | NR | NR | NR | | Within 1 year: 14/28 (50%)  \*One patient underwent 2 tracheostomies  (The cause of death was pulmonary in most cases) | Within 1 year: 1/4 (25%)  \*One patient underwent 2 tracheostomies  (The cause of death was pulmonary in most cases) | 39 pulmonary complications | 8 pulmonary complications | | NR | NR | NR | NR | NR | NR | NR | NR | 2/32 (6.3%) complications (minor bleed and tracheal stenosis)  \*Paper stated 33 procedures but data from tables suggested only 32 procedures were performed | |
| **Beom 2018[[3]](#endnote-3)** | 10/10  (100%) | 12/12  (100%) | NR | NR | NR | NR | NR | NR | | NR | NR | NR | NR | | 6.0 | 6.9 | NR | NR | NR | NR | 11.4 | 19.7 | No surgical site infections for patients with tracheostomy | |
| **Choi 2013** | 10/10 (100%) | 11/11  (100%) | NR | NR | NR | NR | NR | NR | | NR | NR | 4/10 (40%) | 9/11 (82%) | | 5.2 (6.5) | 29.2 (22.9) | NR | NR | 77.2 (27.9) | 78.5 (54.3) | Total ICU stay: 20.8 (6.0)  Post-tracheostomy ICU stay: 6 (4.3) | Total ICU stay: 38 (18.5)  Post-tracheostomy ICU stay: 15.3 (19.6) | 0/10 (0%) | 1/11 (9%) |
| **Flanagan 2018** | 37/37 (100%) | 33/33 (100%) | 1/37  (2.7%)[[4]](#endnote-4) | 1/33  (3.0%) | NR | NR | 6.3%[[5]](#endnote-5) | 3.5% | | NR | NR | 14/37(37.8%) | 15/33  (45.5%) | | 23.9 (16.5)[[6]](#endnote-6) | 36.9 (26.7) | NR | NR | NR | NR | 20.7 (6.5) | 26.0 (11.4) | No surgical site infections in any patients that underwent anterior approach cervical spine fixation. No difference in 90-day readmission rates (31% in early group and 30.8% in late group) | |
| **Galeiras 2018** | 31/31 (100%) | 25/25 (100%) | 8/31 (25.8%)[[7]](#endnote-7) | 2/25 (8%) | NR | NR | NR | NR | | NR | NR | NR | NR | | 66.0 +/-68.7/40.0[[8]](#endnote-8) | 66.4 +/- 61.9/45.0 | 14.4 +/- 10.4/11.0 | 10.5 +/- 7.1/11.0 | 190.8 (121.9/198.0) | 245.6 (125.5/233.0) | 32.9 +/-11.0/30.0 | 35.2 +/-19.4/28.0 | 3/31 (9.7%) | 4/25 (16.0%) |
| **Ganuza 2011** | 101/101  (100%) | 114/114 (100%) | NR | NR | 1/101 (1%)[[9]](#endnote-9) | 4/114 (3.5%) | NR | NR | | NR | NR | 75 (74.2%) | 83 (72.8%) | | Total: 26.1 +/- 11.7  Post-tracheostomy: 22.1 (11.2) | Total: 48.8 +/- 13.5  Post-tracheostomy: 34.0 (12.3) | NR | NR | NR | NR | Total ICU stay: 36.5 +/- 21.6  Post-tracheostomy ICU stay: 30.6 (19.6) | Total ICU stay: 54.6 +/- 24.9  Post-tracheostomy ICU stay: 39.3 (23.0) | 21/101 (21%)[[10]](#endnote-10) | 32/114 (28%) |
| **Guirgis 2016** | High CSCI: 32  Low CSCI: 19  51/51 (100%) | High CSCI: 13  Low CSCI: 5  18/18 (100%) | NR | NR | High CSCI: 2/32 (6.3%)  Low CSCI: 3/19 (15.8%) | High CSCI: 5/13 (38.5%)  Low CSCI: 1/5 (20%) | NR | NR | | NR | NR | NR[[11]](#endnote-11) | NR | | High CSCI: 9.3 (7.2)  Low CSCI: 12.1 (10.4) | High CSCI: 13.7 (3.2)  Low CSCI: 25.2 (17.7) | NR | NR | NR | NR | High CSCI: 19.1 (32.7)  Low CSCI: 23.4 (27.8) | High CSCI: 18.2 (5.2)  Low CSCI: 33.6 (31.8) | NR | NR |
| **Holscher 2014** | All: 43/43 (100%)  Age <12: 11/11 (100%)  Age 13-18: 32/32 (100%) | All: 48/48 (100%)  Age <12: 18/18 (100%)  Age 13-18: 30/30 (100%) | NR | NR | NR | NR | NR | NR | | NR | NR | All: 25/43 (58%)  Age <12: 2/11 (18%)  Age 13-18: 23/32 (72%) | All: 31/48 (65%)  Age <12: 9/18 (50%)  Age 13-18: 22/30 (73%) | | All: 14 (11-17)[[12]](#endnote-12)  Age <12: 9 (5-14)  Age 13-18: 15 (10-20) | All: 21 (18-24)  Age <12: 23 (17-28)  Age 13-18: 19 (16-23) | NR | NR | All: 26 (22-30)[[13]](#endnote-13)  Age <12: 18 (13-23)  Age 13-18: 30 (22-40) | All: 37 (29-50)  Age <12: 31 (26-36)  Age 13-18: 40 (28-56) | All: 19 (16-22)  Age <12: 13 (8-20)  Age 13-18: 19 (13-26) | All: 27 (23-32)  Age <12: 25 (21-30)  Age 13-18: 27 (21-35) | All: 2/43 (5%)[[14]](#endnote-14)  Age <12: 0/11 (0%)  Age 13-18: 2/32 (6%) | All: 10/48 (21%)  Age <12: 5/18 (28%)  Age 13-18: 5/30 (17%) |
| **Jeon 2014** | 39/39 (100%) | 86/86 (100%) | NR | NR | 1/39 (2.6%) | 4/86 (4.7%) | 2/39 (5.1%) | 6/86 (7.0%) | | NR | NR | Pneumonia: 2/39 (5.1%)  ICUAP: 1/39 (2.6%)  VAP: 1/39 (2.6%) | Pneumonia: 16/86 (18.6%)  ICUAP: 10/86 (11.6%)  VAP: 6/86 (7.0%) | | 11.4 (5.6) | 21.5 (15.5) | NR | NR | 70.6 (48.0) | 71.6 (54.6) | 19.9 (10.6) | 31.1 (18.2) | 1/39 (2.6%) | 2/86 (2.3%) |
| **Khan 2020** | 280/280 (100%) | 859/859 (100%) | NR | NR | NR | NR | 12/280 (4.3%) | 49/859 (5.7%) | | NR | NR | 27/280 9.5% | 139/859 (16.1%) | | 15 (4-21) | 19.5 (12-25) | NR | NR | 18 (13-25) | 28 (22-38) | 14 (8-23) | 23 (16-30) | NR | NR |
| **Kornblith 2013** | 57/57 (100%) | 61/61 (100%) | 7/57 (12.3%) | 1/61 (1.6%) | NR | NR | NR | NR | | NR | NR | 34/57 (59.7%) | 43/61 (70.5%) | | NR\* | NR\* | NR | NR | 24 (18-37) | 33 (24-37) | 18 (13-29) | 27 (20-36) | NR | NR |
| **Leelapattana[[15]](#endnote-15)** | 41/66 (62.1%). underwent tracheostomy | | NR | NR | NR | NR | NR | NR | | NR | NR | NR | NR | | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| **Lozano** | 39/39 (100%) | 59/59 (100%) | NR | NR | NR | NR | 4/39 (10.3%) | 1/59 (1.7%) | | NR | NR | NR | NR | | NR | NR | NR | NR | No statistically significant difference  in hospital or ICU LOS, however, trend toward longer LOS for LT[[16]](#endnote-16) | | | | 0/39 (0%)[[17]](#endnote-17) | 5/59 (8.47%) |
| **Romero 2009** | 71/71 (100%) | 81/81 (100%) | 1/71 (1.4%)[[18]](#endnote-18) | 5/81 (6.2%) | NR | NR | NR | NR | | NR | NR | During intubation: 32/71 (45.1%)  Post tracheostomy: 53/71 (74.6%)  Total: 62/71 (87.3%) | During intubation: 66/81 (81.5%)  Post tracheostomy: 59/81 (72.8%)  Total: 76/81 (93.8%) | | Total time: 26.07 (1.69)  Post tracheostomy: 22.14 (1.18) | Total time: 48.75 (3.45)  Post tracheostomy: 33.96 (3.30) | NR | NR | NR | NR | Total: 36.52 (1.59)  Post-tracheostomy: 30.60 (1.64) | Total: 54.58 (2.92)  Post-tracheostomy: 39.27 (2.95) | Total: 22/71 (30.99%)  Granuloma: 2/71 (2.81%)  Concentric tracheal stenosis: 1/71 (1.41%) | Total: 42/81 (51.85%)  Granuloma: 10/81 (12.34%)  Concentric tracheal stenosis: 13/81 (16.05%) |
| **Vitaz 2001[[19]](#endnote-19)** | The number of patients in the CP group (36 patients) who underwent tracheostomy was not specified | The number of patients in the control group (22 patients) who underwent tracheostomy was not specified | NR | | NR | NR | NR | NR | | NR | NR | 24/36 (66.7%)[[20]](#endnote-20) | 19/22 (86.4%) | | 12.8 (11.6) | 18.8 (12.9) | NR | NR | 24.4 (13.5) | 35.9 (16.7) | 21.2 (12.7) | 28.0 (13.1) | Decubitus ulcers: 9 (25)  Stage III ulcers: 0 (0) | Decubitus ulcers: 12 (54)  Stage III ulcers: 3 (14) |
| **Wu 2013[[21]](#endnote-21)** | 11/11 (100%) | 19/43 (44.2%) | 1/11  (9.1%)[[22]](#endnote-22) | 12/43  (27.9%) | NR | NR | NR | NR | | NR | NR | 1/11  (9.1%)[[23]](#endnote-23) | 3/43  (7.0%) | | Unknown | Unknown | Unknown | Unknown | 10.3 (4.0) | 16.5 (9.2) | NR | NR | 0/11 (0%) | 1/43 (2.3%) |

**Supplemental Appendix 9 – Subgroup Analysis Short-Term Mortality**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Outcomes** | **Number of studies** | **Number of patients providing data** | **Effect estimate [95% CI]** | **P value for effect estimate** | **I2 (%)** |
| **Short-term mortalityby study publication year** | | | | | |
| <2015 [8,11–14] | 5 | 664 | 0.66 [0.20, 2.17] | 0.49 | 47 |
| 2015-2020 [1,3,15–17] | 5 | 1,408 | 1.04 [0.34, 3.18] | 0.94 | 64 |
| Z test for subgroup interaction not statistically significant (p = 0.65) | | | | | |

1Short-term mortality is defined as mortality occurring in-hospital and reported as either ICU or hospital mortality

CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 10 – Duration of Mechanical Ventilation**

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**Fig.1.** Random effects meta-analysis onduration of mechanical ventilation (MV), expressed as the mean difference (MD) in days. The green box represents the point estimate of the study result, the black horizonal line represents the 95% confidence interval of the study result, and the black diamond represents the mean point estimate and mean confidence interval of all the studies. ET=Early tracheostomy, LT=Late tracheostomy, CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 11 – ICU Length-of-Stay**

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**Fig. 4.** Random effects meta-analysis onICU length-of-stay (LOS), expressed as the mean difference (MD) in days. The green box represents the point estimate of the study result, the black horizonal line represents the 95% confidence interval of the study result, and the black diamond represents the mean point estimate and mean confidence interval of all the studies. ET=Early tracheostomy, LT=Late tracheostomy, CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 12 – Hospital Length-of-Stay**

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**Fig.3.** Random effects meta-analysis on hospital length-of-stay (LOS), expressed as the mean difference (MD) in days. The green box represents the point estimate of the study result, the black horizonal line represents the 95% confidence interval of the study result, and the black diamond represents the mean point estimate and mean confidence interval of all the studies. ET=Early tracheostomy, LT=Late tracheostomy, CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 13 – Incidence of Ventilator-Associated Pneumonia**

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**Fig. 2.** Random effects meta-analysis onventilator-associated pneumonia (VAP), expressed as the risk ratio (RR). The blue box represents the point estimate of the study result, the black horizonal line represents the 95% confidence interval of the study result, and the black diamond represents the mean point estimate and mean confidence interval of all the studies. ET=Early tracheostomy, LT=Late tracheostomy, CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 14 – Tracheostomy-Related Complications**

**Table

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**Fig.5.** Random effects meta-analysis ontracheostomy-related complications expressed as the risk ratio (RR). The blue box represents the point estimate of the study result, the black horizonal line represents the 95% confidence interval of the study result, and the black diamond represents the mean point estimate and mean confidence interval of all the studies. Choi et al. reported a case of tracheal stenosis. Galeiras reported a case of a peri-/paravertebral abscess in the early tracheostomy group, a case of bleeding in the late tracheostomy group, and two cases of stenosis and a case granuloma in both groups. Ganuza et al. reported 15 cases of stomal cellulitis, 6 cases of bleeding, and 3 cases of tracheal stenosis in the early tracheostomy group. There were 13 cases of stomal cellulitis, 8 cases of bleeding, and 16 cases of tracheal stenosis in the late tracheostomy group. There was also a case of tracheoesophageal and a mediastinal abscess. These complications occurred in 21 patients and 32 patients in the early and late tracheostomy groups, respectively. Holscher reported 13 cases of airway complications in 12 patients, which consisted of 6 cases of tracheitis, 2 cases of subglottic stenosis, 1 case of endotracheal granuloma, 1 case of glottis granuloma, 1 case of tracheomalacia, 1 case of arytenoid dislocation, and 1 case of vocal cord hypofunction. There was no difference in prevalence of tracheitis between those undergoing early versus late tracheostomy (5% versus 8%, p = 0.7). Excluding tracheitis, all airway complications were seen in patients who received late tracheostomy (p = 0.03). Jeon reported tracheostomy site infection. Lozano et al. reported 5 cases of cervical fusion site infection (4 involving the posterior cervical fusion, and 1 involving the anterior cervical fusion which was subsequently associated with an esophagocutaneous fistula). Romero et al. reported complications including bleeding, stoma infection, suture dehiscence, granuloma, concentric tracheal stenosis. Wu et al. reported surgical incision site infection. ET=Early tracheostomy, LT=Late tracheostomy, CI=Confidence interval, I2=Study heterogeneity

**Supplemental Appendix 15 – References**

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1. 9 of the 20 tracheostomy patients in the study underwent early trach while 9 underwent late trach (for a total of 18/20 patients). It is unclear why the remaining two patients were excluded from the early and late groups (it may have been the 2 patients that died during the initial hospital stay, or the 2 patients that had degenerative disc disease). [↑](#endnote-ref-1)
2. Long-term mortality measured at a median of 12.5 months. [↑](#endnote-ref-2)
3. While descriptive statistics (arithmetic mean, SD, range) were calculated, they were not reported for the data included in this table. [↑](#endnote-ref-3)
4. Short-term mortality was defined as mortality upon initial admission [↑](#endnote-ref-4)
5. Hospital mortality was defined as 90-day mortality in this study [↑](#endnote-ref-5)
6. The finding of significantly decreased MV duration in the early tracheostomy group was consistent when AIS and neurological level of injury were controlled for. [↑](#endnote-ref-6)
7. The authors reported mortality during admission, which was included here as short-term mortality. [↑](#endnote-ref-7)
8. Duration of MV, duration of sedation, and ICU LOS were recorded as mean +/- SD/median. [↑](#endnote-ref-8)
9. The timing of mortality was not specified, however as the authors specified patients were in the ICU and ICU LOS was reported while hospital LOS was not, mortality has been recorded in this table as ICU mortality. [↑](#endnote-ref-9)
10. 25 complications occurred in 21 patients of the early tracheostomy group and 38 complications occurred in 32 patients of the late tracheostomy group. In 3% of the total number of patients these complications were moderate to severe, and included tracheal stenosis, tracheoesophageal fistula, and mediastinal abscess. Stomal cellulitis occurred in 14.9% of patients in the early tracheostomy group and 11.4% in the late tracheostomy group. Bleeding occurred in 5.9% of patients in the early tracheostomy group and 7.0% in the late tracheostomy group. Tracheal stenosis occurred in 3% of patients in the early tracheostomy group and 14.0% in the late tracheostomy group. [↑](#endnote-ref-10)
11. 11 patients in the study developed pneumonia, while 4 developed VAP. However, the differences in pneumonia and VAP between the early and late tracheostomy groups (both high and low CSCI) were not reported. [↑](#endnote-ref-11)
12. Duration of mechanical ventilation was not reported, however ventilator-free days (out of 28 days) were (as the median and inter-quartile range): 0 (0-12) for the early tracheostomy group and 0 (0-6) for the late tracheostomy group. [↑](#endnote-ref-12)
13. Both hospital and ICU LOS were reported as median (inter-quartile range). [↑](#endnote-ref-13)
14. Airway complications included tracheitis, subglottic stenosis, endotracheal granuloma, glottis granuloma, tracheomalacia, arytenoid dislocation, and vocal cord hypofunction. Tracheitis accounted for all of the airway complications that occurred in the early tracheostomy group. [↑](#endnote-ref-14)
15. Positive correlations were found between the time from injury to tracheostomy with both duration of MV after injury and hospital LOS (r=0.346; p= 0.038, and r=0.465; p=0.004, respectively). Specifically, when age, ISS, and complete SCI were adjusted for it was found that for every additional day from injury to tracheostomy the hospital LOS increased by 2.3 days. Patients who died within 7 days following injury were excluded from the study. [↑](#endnote-ref-15)
16. The mean length of ICU and hospital stay was 20 and 31 days, respectively, with no significant difference in either outcome between early or late tracheostomy groups. [↑](#endnote-ref-16)
17. Of the 5 cervical fusion surgical site infections (recorded in the table as laryngotracheal complications) that occurred in the late tracheostomy group, 4 involved the posterior cervical fusion while the final complication entailed an anterior cervical fusion surgical site infection due to an esophagocutaneous fistula. [↑](#endnote-ref-17)
18. The timing of mortality was not specified. [↑](#endnote-ref-18)
19. The Clinical Pathway entailed performing tracheostomy for ventilator-dependent patients on approximately post-injury day 4. [↑](#endnote-ref-19)
20. The average number of episodes of pneumonia/patient was significantly lower in the Clinical Pathway group (1.1% vs. 1.6%). [↑](#endnote-ref-20)
21. Unable to access the full-text of this study. [↑](#endnote-ref-21)
22. The timing of mortality rate reported in the study was not specified, and so has been included here as short-term mortality [↑](#endnote-ref-22)
23. The study reported incidence of pulmonary infection, which has been recorded in this table as VAP, while the reported incidence of surgical site infection has been included here as laryngotracheal complications. [↑](#endnote-ref-23)