Author Year Study Design	Population Characteristics	Methods	Outcomes
[Aarabi et al. 2012](#) USA Case series Level 4 N = 109	**N:** 109 **Level:** C2-C4: 47 C5-T1: 40 T2-T12: 14 L1-S1: 8 **AISA Impairment Scale Grade:** A: 48 B: 16 C: 13 D: 32 **Etiology:** Motor vehicle accidents, falls, sports and other. **Mean Age (SD):** 42.76 ± 16.7 **Median Time since Injury (IQR):** ± **Female:** n=23	**Study Duration:** 2005 – 2009 **Outcome Measures:** Pulmonary complications. **Objectives:** Define and analyze the predictors of moderate and severe pulmonary complications following SCI and investigate whether pulmonary complications negatively affected the ASIA Impairment Scale conversion rate in patients with SCI.	1. Eighty-seven pulmonary complications occurred in 51 patients. a. Twenty-six patients had ventilatory failure. b. Twenty-five had pneumonia. c. Seventeen had pleural effusion. d. Six had acute lung injury. e. Four had pneumothorax. f. Four had lobar collapse. g. Pulmonary embolus and hemothorax were each encountered in 2 patients, and 1 patient had a mucus plug. 2. Patients with sports injuries and those between the ages of 26 and 35 years were particularly prone to pulmonary complications and had an RR of 1.65 and 1.73, respectively (p = 0.04). Individuals with ASIA motor scores less than 25 were almost 9 times more at risk of pulmonary

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			complications than those with an ASIA motor score more than 50 (RR 8.7, p < 0.0001). Similarly, patients with ASIA Impairment Scale Grade A scores had more pulmonary complications (RR 8.2, p < 0.0001). Patients with complete SCI were 3 times more prone to pulmonary complications than patients with incomplete injuries (RR 3.36, p < 0.0001). As the single neurological level of injury ascended from S-1 to C-2, the rate of pulmonary complications increased concordantly. 3. The degree of maximum canal compromise in the spinal canal and maximum spinal cord compression did not influence the occurrence of pulmonary complications. However, as the length of intramedullary lesion on T2-weighted MRI studies exceeded 40 mm, the risk of pulmonary complications also

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			increased by a factor of 2 (p = 0.004).
			4. Patients with pulmonary complications had significantly longer LOSs (40.7 vs. 12.8 days, p = 0.05).
			5. The overall rate of conversion in patients with moderate or severe pulmonary complications was 37.2%, similar to 31% in patients without moderate or severe pulmonary complications.
			6. Controlling for age, mechanism of injury, neurological level, and length of intramedullary lesion, only the admission ASIA Impairment Scale grade predicted moderate or severe pulmonary complications; patients with increasing severity of ASIA Impairment Scale grade had a markedly increased risk. Patients with Grade A were nearly 10 times as likely, those with Grade B were 2.6 times as likely, and those with Grade C were 1.7 times as likely to have a moderate or severe

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			pulmonary complication compared with those with Grade D.
[Josefson et al. 2021](#) Sweden Case series Level 4 N = 136	**N:** 136 **Level:** Cervical: 83 Thoracic-sacral: 53 C1-C4 AIS ABC: 22 C5-C8 AIS ABC: 23 T1-S5 AIS ABC: 34 AIS D: 44 **Etiology:** traumatic (84%): fall (33%) Non-traumatic: infection (5%) or vascular (5%) **Median Age (IQR):** 51 (33-65) **Median Time since Injury (IQR):** **Female:** 22%	**Study Duration:** Admitted between Jan 2010 and Dec 2014. Follow up on mortality ended 2018 **Outcome Measures:** AIS and Charlson Comorbidity index, Breathing aid defined as (non-invasive ventilation [NIV]; CPAP [continuous positive airway pressure]; Bi-level PAP, BiPAP), tracheostomy (TOT), use of cough assist machine, ICD codes **Objectives:** To determine prevalence of respiratory complications in people with SCI during the initial rehabilitation at the spinal cord injury unit (SCU) and to describe the subsequent effect on mortality.	1. 38% required some breathing aid during their initial rehabilitation period in the SCU 2. 40% had acute respiratory complications during their stay in the SCU. Pneumonia was diagnosed in 35% 3. More than half of the participants with cervical SCI (n = 43) had respiratory complications during their initial rehabilitation in the SCU, and 20% (n = 11) of participants with lower injuries experienced the same 4. Of the 23% deceased at follow-up, respiratory causes contributed to one-third of the deaths (n = 10). 5. The RR of dying if the person suffered from any respiratory complications during their initial rehabilitation in the SCU was 2.1 times higher than for those with no respiratory complications (RR, 2.10;

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			95% CI, 1.1–3.9). While a history of pneumonia was associated with 72% higher mortality, this was not statistically significant (RR, 1.72; 95% CI, 0.9–3.2). 6. A history of respiratory complications in the SCU was associated with a higher mortality and a tendency of a shorter life span ($p > 0.05$) 7. Of the 10 who died from respiratory causes, 8 suffered from pneumonia during their initial rehab in the SCU and had a 4.3 times higher risk (RR, 4.27; 95% CI, 1.1–16.9) of dying from respiratory causes later compared to those who did not suffer from pneumonia at the SCU. 8. 6 of 10 participants required use of the cough assist machine during their stay in the SCU, which also indicated a significantly higher risk of death due to respiratory causes (RR, 3.15; 95% CI, 1.1–8.7).

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[Mueller et al. 2008](#) Netherlands (8 SCI rehab centers) Prospective cohort study Level 2 N = 109	**N:** 109 **Level:** Acute, motor complete SCI (ASIA A or B) included **Etiology:** **Mean Age (SD):** 38 +- 14 **Median Time since Injury (IQR):** **Female:** n=28 *Subgroups: High tetraplegia (HT [C3-C5]) Low tetraplegia (LT [C6- C8]) High paraplegia (HP [T1-T6]) Low paraplegia (LP [T7- T12])	**Study Duration:** Between Aug 2000 and July 2003. Assessments at first mobilization, discharge and 1 year after discharge **Outcome Measures:** 1. Lung function (FVC, FEV_1, FIV_1, PEF, PIF) 2. Respiratory muscle pressure generating capacity (PI_{max}, PE_{max}) **Objectives:** To investigate the time-courses of lung function and respiratory muscle pressure generating capacity after SCI.	**Longitudinal changes:** 1. FVC and FEV_1 increased in all four groups until one year after discharge from inpatient rehabilitation. 2. FIV_1, PEF and PIF generally remained constant during the first year after discharge. 3. PI_{max} showed significant increases during and after inpatient rehabilitation, while PE_{max} showed significant increases only in participants with paraplegia during inpatient rehabilitation. **Influence of lesion** 1. HT showed significantly lower FVC, FEV_1, FIV_1 and PEF values than LT while these values were significantly higher for LP than LT. 2. There were no significant differences between LT and HP in any of the tested lung function parameters. 3. PE_{max}, PI_{max} and P_{endu} were lower in participants with tetraplegia compared to participants with paraplegia. 4. PE_{max} of participants with tetraplegia did not change over time, PE_{max}

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			of participants with paraplegia increased during inpatient rehabilitation but decreased thereafter. **Influence of personal factors** 1. Personal factors such as gender, age and height had significant influences on all lung function parameters, except age had no influence on PEF (PEF seems not to decrease with age). 2. Body mass and smoking had no significant effect on any of the measured parameters. 3. PI_{max} and PE_{max} were only influenced by gender which resulted in higher estimates for men than for women.
[Shavelle et al. 2006](#) USA Retrospective (25 SCI centres) Level 4 N = 810	**N:** 810 people, 319 first year survivor (SCI who are ventilator dependent at discharge) **Level:** ASIA A: 74 ASIA B: 13 ASIA C: 8	**Study Duration:** 1986 person years occurring from 1973 to 2003. Patients with SCI from inpatient rehab who survive at least 1 year after injury. **Outcome Measures:** Mortality, cause of death, neurologic level of injury	1. Even in a population limited to ventilator-dependent persons, those with the most severe injury grade (ASIA A) had poorer survival. 2. The C1-C5 ASIA A group was at 2.268 (OR) times greater odds of dying than among ventilator-dependent persons who were not C1-C5 ASIA A (p=0.0002).

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	ASIA D/unknown: 6 **Etiology:** Fall (n=22), MVA (40), sports (15), violence (13), other (10) **Age (n):** 20-49: 74 50-79: 26 80+: 0 **Median Time since Injury (IQR):** **Female:** 18%	**Objectives:** Identify factors related to long-term survival, and quantify their effect on mortality and life expectancy	3. C1-C5 ASIA B injuries had a significantly better prognosis than C1-C5 ASIA A (OR = 0.45, P < 0.05), and C5 was similar to C1-C4. Our impression was that many persons with injuries at levels C6 and lower are eventually weaned from ventilator dependence after discharge, whereas comparatively fewer of the C1-C5 ASIA A persons are subsequently weaned. 4. Life expectancy among the ventilator-dependent persons decreases both with age and severity of injury. For example, the life expectancy is 18.6 years for a 30-year-old who has a C1-C5 ASIA A injury but only 2.2 years for an 80 year old. 5. Cause of death was known for 84 of 121 cases (69%). Pneumonia and other respiratory diseases were the main cause of death 26 (31 %).
[Postma et al. 2016](#) Netherlands Follow-up of prospectiv	**N:** 147 **Level:** Motor complete (AIS A and B) tetraplegia: 33	**Study Duration:** 5 year follow up of prospective cohort study. Admission to rehab was between	1. 30.9% of all people had impaired FVC (below 80% of the predicted value), 35.9% perceived poor or moderate cough strength and 18.4% (at rest) and 29.0%

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e cohort (8 rehab centers) Level 2 N = 147	Incomplete (AIS C and D) tetraplegia: 21 Motor complete (AIS A and B) paraplegia: 67 Incomplete (AIS C and D) paraplegia: 26 **Etiology:** Traumatic (78.9%) **Mean Age (SD):** 45.5 (13.8) **Mean Time since Injury (SD):** 6.6 (0.8) yr **Female:** 28.6%	Aug 2000 and July 2003 **Outcome Measures:** 1. Pulmonary function (FVC) 2. Respiratory function (self-report cough strength and dyspnea) 3. HRQOL (sickness impact profile 68 [SIPSOC] and SF-36) 4. Respiratory infections (RI) **Objectives:** Examine the prevalence of impaired respiratory function (objective pulmonary and perceived respiratory function), the incidence of RI and the associations among these parameters in people with SCI 5 years after initial inpatient rehab. Secondly, assess the associations between respiratory function and HRQOL (expressed as: social functioning, general health, mental health, and vitality).	(during activity) experienced dyspnea (occasionally, regularly, or often). 2. When corrected for the lesion level and completeness, people with lower FVC (p=0.04), poor perceived cough strength (p=0.02) and more dyspnea at rest and during physical activity (p<0.001) reported more limitations in social functioning (SIPSOC). 3. People with dyspnea at rest reported lower general health (occasional dyspnea, p=0.03; regular, p=0.02) mental health (regular dyspnea, p=0.04) and vitality (regular, p=0.08). General health was lower in those with regular dyspnea than in occasional dyspnea at rest (beta-coefficient, -12.1 vs. -27.6, respectively). 4. People with dyspnea during physical activity reported lower general health (occasional dyspnea, p=0.02; regular, p=0.04) mental health (occasional dyspnea, p=0.01; regular dyspnea, p=0.03) and vitality (occasional dyspnea, p=0.01;

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			regular, p=0.05). General health, mental health and vitality range were lower in those with regular dyspnea than in occasional dyspnea.
[Mueller et al. 2012](#) Netherlands (8 centers) and Switzerland (9 SCI centers) Cohort Level 2 N = 440	**N:** 440 **Level:** Motor complete AIS A or B with lesion level C4-T12 included **Etiology:** Traumatic **Median Age:** 47 (21-72) **Median Time since Injury:** 15.7 (0.7-40.9) yr **Female:** n=89	**Study Duration:** **Outcome Measures:** 1. Lung function (FVC, FEV_1, PEF) 2. Respiratory muscle strength tests (Peak inspiratory and expiratory muscle strength [PI_{max}, PE_{max}]) **Objectives:** To develop statistical models to predict lung function and respiratory muscle strength from personal and lesion characteristics of participants with motor complete SCI.	**Revised summary:** A lower lesion level positively predicts lung function and respiratory muscle strength in participants with motor complete SCI. Younger age, being male, heavier, and tall were also significant positive predictors of lung function parameters. PI_{max} was positively predicted by younger age, being male, and being heavier, while PE_{max} was positively predicted from younger age, being male, and a greater time since injury. 1. Group means of FVC, FEV_1 and PEF values increased with lower lesion level, but showed a large range between participants of the same group. 2. Multivariate analysis - all lung function parameters are significantly associated with the level of injury (p<0.05) but showed a large range between participants of the same group. Individuals

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			with lower lesion levels showed higher values than participants with higher lesion levels. Men showed significantly higher values than women, younger participants showed higher values than older ones, taller and heavier participants showed higher values than smaller and lighter ones. Time post injury and the interaction of lesion level and age had no significant influence on any of the tested lung function parameters. R2 for FVC was 0.55, for FEV_1 0.52 and for PEF 0.40. 3. Group means of PI_{max} and PE_{max} increased with lower lesion level, but also showed a large range between participants of the same group. Participants with lower lesion levels showed higher values than those with higher lesion levels, and men showed higher values than women. Increasing age had a negative influence on PI_{max} and PE_{max}, whereas greater body mass was positively associated

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			with PI_{max} but not with PE_{max}. Height and time post injury had no significant influence on PI_{max}. PE_{max} was positively associated with time post injury. The total variance of the models that can be explained by included factors (R2), was 0.37 for PE_{max} and 0.46 for PE_{max}.
[Garshick et al. 2005](#) USA Prospective cohort study Level 2 N = 361	**N:** 361 males **Level (survivors):** _Incomplete_ Cervical ASIA C 35: Cervical ASIA D: 40 Other ASIA C: 25 Other ASIA D: 32 _Complete_ Cervical: 69 High thoracic (T1–T4): 48 Low thoracic (T5–T12): 40 Others: 35 **Etiology:** Non-traumatic (6.5%) - infection (n=5), disc disease or spinal stenosis (3), tumor (4),	**Study Duration:** Between 1994 and 2000. SCI males >= 1-year post-injury. Participants were followed for a median of 55.6 months (interquartile range 42.0–67.5 months; range 0.33–74.4 months) **Outcome Measures:** 1. Health questionnaire 2. Pulmonary function (FEV_1, FVC, MEP, MIP) 3. National death index **Objectives:** To assess the relationship between comorbid medical conditions and other health related factors to mortality in chronic	1. Respiratory system deaths accounted for only 5.4% of the underlying causes of death. 2. Specific underlying and contributing respiratory deaths included pneumonia (n = 4), chronic airways obstruction (n = 3), pleural effusion (n = 1), and unspecified respiratory complications (n = 1). 3. After adjusting for age, any wheeze was a significant predictor (RR 1.54 unadjusted, 2.38 adjusted) and persistent wheeze was a borderline predictor (RR 2.06 unadjusted, 1.87 adjusted) of mortality. 4. After adjusting for age, percent-predicted FEV_1 (RR 0.97) and percent-predicted FVC (0.97)

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	six occurred following an unspecified operation, other cause (4) **Mean Age (SD):** 50.6 +- 15.0 at entry **Mean Time since Injury:** 17.5 +- 12.8 yrs at entry **Female:** 0	spinal cord injury (SCI).	were related to mortality. Age-adjusted models for FEV_1 and FVC indicated that for each percent predicted increase in lung function, mortality decreased by 3%. 5. In the 348 participants with pulmonary function data available, significant predictors of mortality included age, percent predicted FEV_1 (RR 0.97), cigarette smoking (current cigarette consumption and smoking ≤ 7 years before study entry), diabetes, and heart disease.

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Cobb et al. 2014 Canada Cross-sectional Level 5 N = 1137	**N:** 1137 **Level**: 50.3% (95% CI 47-53) paraplegia, 49.7% (95% CI 47-53) tetraplegia, 39.1% (95% CI 36-42) complete, 60.9% (95% CI 58-64) incomplete **Etiology:** traumatic **Age:** 48.3 ± 13.3 years **Duration:** 18.4 ± 16.3 years **% Female:** 29.1% (95% CI 27-32)	**Timeline:** May 2011-Aug 2012 **Outcomes:** Two instruments, the SCI Health Questionnaire: Secondary Complications (SCI-HQ) and the person-perceived Participation in Daily Activities Questionnaire (PDAQ), that were originally created for the Rick Hansen SCI Registry Community Follow-Up Questionnaire V2.0. **Objective:** describe the association between secondary health complications and the ability to participate in daily activities among SCI people.	1. RI were associated with 18 daily activities. With all secondary health outcomes included, the RR values ranged from 1.15 to 2.53; this was a 15% to 153% increased probability of not participating as much as wanted in a particular DA, when a specific SHC is present.
Hirschfeld et al. 2008 Germany Prospective cohort Level 2 N = 64	**N:** 64 (32 PNS, 32 MV) **Level:** AIS A: 57 AIS B: 2 AIS C: 5 C0: 8 C2: 47	**Study Duration:** Prospective data collection of treatment-related data over 20 years. Patients treated from 1987 through 2006. All patients were screened for check-up once a year	1. Duration of rehabilitation was equal for patients on PNS (249 (7–1303) days) and patients on MV (290 (4–582) days). 2. Total 12 patients on PNS and 14 on MV died during the observation period (P = 0.1023); of

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	C3: 9 **Etiology:** **Median Age (range):** PNS: 29 (9-71) MV: 53 (6-77) **Time since Injury:** **Female:** n=18	**Outcome Measures:** 1. RI 2. Quality of speech 3. Presocial conditions 4. LoS **Objectives:** To compare MV with PNS for treatment of respiratory device-dependent patients with SCI	these, 3 with PNS and 10 with MV died of RI (P = 0.0472). 3. Regarding RI, there is no significant difference between groups in period 1. However, during both 'post implantation' periods, 2 and 3, there are significantly fewer RIs with PNS than with MV (p<0.001). 4. There is no difference between PNS and MV for the ability to talk. The quality of speech is significantly better with PNS, where the lowest score was 3 (6 (5.25–6)), than with MV, where speech scores were frequently 1 and 2 (3.5 (2–5.75)) (P<0.001). 5. Seven patients on PNS and two on MV returned to School or High School, two patients on PNS but none on MV returned to work and all others retired.
[Kornblith et al. 2013](#) USA Case series Level 4 N = 344	**N:** 344 **Level:** Cervical injury: 222 (64.5%) Thoracic injury: 90 (26.2%) Lumbar injury:	**Study Duration:** 14 trauma centers from 2005–2009 were evaluated **Outcome Measures:** Primary outcome: Need for MV at	1. The majority (71.8%) did not require MV at the time of discharge. 2. The overall cohort had a high rate of VAP (38.1%), and patients with cervical SCI had significantly higher rates of ventilator-

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	32 (9.3%) Complete injury: 172 (20.0%) **Etiology:** **Median Age (range):** 43 (18-90) **Time since Injury:** **Female:** 19.5%	discharge. Secondary outcomes: Use of TOT, acute lung injury, and ventilator-associated pneumonia based on consensus definitions **Objectives:** Performed a multicenter cohort study to examine the predictors of ventilator dependence at discharge in patients with acute SCI	associated pneumonia than those with thoracic or lumbar injuries (cervical 45.1%, thoracic 32.2%, lumbar 6.3%, p<0.05). 3. Over half of the patients with high cervical SCI were off the ventilator at discharge (53.3%) 4. A higher percentage of patients were on MV at discharge in the TOT group compared to those who never underwent a TOT (85.6% vs. 53.7%, p<0.05). 5. As expected, patients requiring MV at discharge had significantly higher rates of ventilator-associated pneumonia (77.8% vs. 28.7%, p<0.05) and acute lung injury (17.5% vs. 4.9%, p<0.05), and longer ICU (25 vs. 10 days, p<0.05) and hospital stays (28 vs. 19 days, p<0.05). 6. In the cervical SCI cohort, we found TOT to be associated with 14.1-fold higher odds of prolonged MV (OR 14.1, CI 2.78–71.67, p<0.05).