Author	Participants	Intervention	Outcomes	Complications
Wijkstra et al. 2022	33 patients with cervical SCI, with a complete or partial dependency on MV; 24 males and 9 females; mean (SD) age 30.6 (± 20.2) years; incomplete Injury (n = 10) and complete injury (n = 22).	DPS laparoscopically.	1. Usage of DPS increased with increasing time of device use. 2. At 6 months, 19 (73.1%) and 11 (42.3%) patients were using DPS for ≥4 and ≥15 h a day, respectively. Six (23.1%) patients used DPS for 24 h a day, and were completely liberated from MV. 3. After further use and acclimation, the number of patients using DPS for ≥4 and ≥15 per day were 17 (77.3%) and 11 (50.0%), respectively, and 8 (36.4%) patients were completely liberated from MV use.	1. Pneumonia was the most common adverse effect and was most commonly seen (63.6%) in patients during the first 3 months post-implant, during a period when they were using MV for time periods ranging from 16 to 24 h/day. 2. Other respiratory events included pneumothorax (n = 3) and atelectasis (n = 2).
Monden et al. 2022	28, C1-C5 high tetraplegia	DPS implant	1. Median DPS use per day was 15.0 hours 2. 4/28 paced hall-time (median time of 5.5 hours breathing indecently per day). 3. 22/28 still used MV when not using their DPS.	Within 2 weeks of DPS implant: 1. 23/28 no complications. 2. 5/28 complications (broken or misplaced leads, needing extra time to heal from surgery, pneumothorax,

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				pneumonia, and adverse reaction to the pacer [sodium / potassium deficiency]). 3. 7/28 additional surgery for complications or DPS malfunction. After 2 weeks of DPS implant: 1. 21/28 no complications. 2. 4/28 pain and infection at the wire sites. 3. 6/28 pneumonia/aspiration. 4. 5/28 spasticity. 5. 26/28 fewer or no changes in the occurrence of aspiration. 6. 24/28 fewer or no changes in infection/pneumonia compared with before implantation.
Onders et al. 2018	92 patients with traumatic SCI (C1-C6)	DPS	1. 81/92 achieved 4 consecutive hours of pacing. 2. 56/92 utilized DP full time 24 hours a day with no MV. 3. 14/92 used DP >12 hours. 4. 5/92 were not successful in weaning off MV.	1. 31/92 deaths. a. 17/31 exact cause of death known. b. In the group in which DP did not allow weaning, 4 of 5 patients died an average of only 9.9 months from injury. 2. Overall survival, from injury, was a

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			5. 24/33 (implanted in the first year) success in being removed from the ventilator 24 hours a day. 6. 22/43 (implanted in second year) success in being able to be off of the ventilator 24 hours a day with DP.	median of 22.2 years (95% confidence interval: 14.0–not reached).
Nandra et al. 2017	4, high cervical SCI tetraplegia with loss of phrenic nerve function and 100% ventilator dependent	Intercostal nerve transfer in diaphragmatic pacing	1. 1/4 pacing up to 24 h per day. 2. 2/4 trials up to 2 h off ventilator 3. 1/4 trials up to 8 h off ventilator.	1. 2/4 none. 2. 1/4 required replacement of leads at 14 months because of hardware malfunction. 3. 1/4 required repositioning of 1 electrode at 5 months because of displacement of the lead. 4. 0/4 infections or reversal to ventilator dependence.
Verin et al. 2017	4 with cervical SCI, and ASIA A tetraplegia	Unilateral diaphragmatic reinnervation by the inferior laryngeal nerve.	During surgery and immediate post-operative care: 1. ICU LOS ranged from 5 to 8 days. 2. Post-operative diaphragm assessments (day 10 and month 1) did not	During surgery and immediate post-operative care: 1. 0/4 early troubles with swallowing. 2. 0/4 significant changes in voice. Follow-up from 6 to 24 months: 1. 1/4 death (unexplained

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			reveal any change. Follow-up from 6 to 24 months: 1. 3/3 showed no changes in nasoendoscopic findings, no swallowing disorders for food or liquid, no episode of laryngeal aspiration or bronchial penetration, and no noticeable change in voice. 2. 3/3 showed bilateral response (diaphragm contraction) to cervical magnetic stimulation at 2 years. 3. 0/3 restoration of automatic ventilation at 36 months.	cardiac arrest at 6 months). 2. 1/4 moderate severe pulmonary embolism, with no distant consequences. 3. 1/4 severe pneumonia with septicemia and urinary tract infection, with complete resolution.
DiMarco et al. 2014	10 participants with complete SCI (8M, 2F). Users of SCS device for >= 2 years Mean (SD) age: 35.6 (13.4) years	Implanted SCS device	1. Significantly greater Maximum expiratory pressure (MEP) during SCS at 1 year and 4.6 (mean) year follow-up, compared to pre-implant	1. Seven of the 10 participants continue to experience mild leg jerks with stimulation, but these are painless and do not interfere with use of the device.

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	Median (SD) DOI: 8.7 (3.5) years		2. Significantly lower frequency of suctioning / assisted cough (S/AC) and severity of S/AC episodes at 1 year and 4.6 (mean) year follow-up, compared to pre-implant 3. Significantly less difficulty and greater ease in raising sputum at 1 year and 4.6 (mean) year follow-up, compared to pre-implant.	
Kaufman et al. 2015	14 patients with SCI ventilated with phrenic nerve lesions; 11M, 3F; Median (range) age: 27 (10-66)	Diaphragmatic pacemaker implantation and bilateral nerve transfer	13 patients showed diaphragm reinnervation; 8 patients achieved >1 h/day ventilator weaning; 2 patients recovered voluntary diaphragm control and spontaneous respiration without pacemaker	No intraoperative complications; 1 patient developed bilateral pleural effusions; 3 patients required revision surgery for replacement ore repositioning of receiver. After final data collection, 1 patient expired due to cardiac arrest, 1 patient stopped pacing.
Hirschfeld et al. 2013	35 (26M, 9F); age at implantation 28 (19) 2–71 yrs	PNS	27 patients (77%) had stable threshold current over an average of 6.3yrs.	Eight of 35 had threshold currents that exceeded 1mA, which might be suggestive of surgical trauma,

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				infection, or reaction to foreign body.
Tedde et al. 2012	5 (3F, 2M) participants with C-SCI; ages 16-40yrs; Level: C2C3 to C4C5	Implantation of a laparoscopic DPS	The diaphragmatic pacemaker placement was successful in all of the patients. After 6 mos, 3 used DPS for 24 hrs, 1 used DPS for up to 6 hrs complemented by MV and 1 discontinued DPS.	Two patients presented with capnothorax during the perioperative period, which resolved without consequences. Diaphragmatic stimulation was discontinued in one patient after onset of uncontrolled neuropathic pain.
Le Pimpec-Barthes et al. 2011	20; 14 males and 6 females, mean age 27.1 years requiring full-time ventilatory support. 18 high cervical spinal injuries above or at C3 level.	Intrathoracic phrenic stimulators.	1. At 36-month follow-up, 18/20 patients had been successfully weaned from the ventilator with a mean weaning time of 6 weeks. 2. All patients who were successfully weaned report an improvement in comfort and QOL.	1. No surgical complications. 2. At 5-year follow-up, 7/20 of participants died (two secondary to pneumonia).
Khong et al. 2010	19 patients (14 with quadriplegia [n = 13] or complete tetraplegia (n = 1))	PNS performed via either a cervical (n = 11) or thoracic approach (n = 6)	1. 11 patients were still actively implanted at the date of study publishment, with total pacing duration ranging from 1 year to 21 years.	1. 1/19 experienced malfunction of the diaphragmatic pacemaker 4 years after initial surgery, requiring ventilation at home. 2. 1/19 required lead replacement on

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			2. The average pacing duration for actively pacing patients in whom records were available was 13 years. 3. Several of the patients were either lost to follow-up or the records were unobtainable.	the right side due to mechanical failure of implanted components and required full ventilation during sleep for 1 month. 3. 1/19 experienced failure of both left-sided and then right-sided receivers due to breast development. 4. Of the patients on whom follow-up information was readily obtained, several complications were noted in most (included recurrent RTI, urinary tract infections, pressure sores, kyphoscoliosis, neurogenic bladder and muscle spasms).
Alshekhlee et al. 2008	26, chronic tetraplegia C1-C4 (25 traumatic, 1 non-traumatic)	DPS	25/26 were able to pace off the ventilator for more than 4 hours per day.	One patient experienced severe muscle cramping and could not achieve conditioning.
DiMarco et al. 2005a	5, ventilator-dependent tetraplegia	Laparascopic placement of intramuscular diaphragm electrodes	4/5 achieved substantial inspired volumes and were maintained without mechanical ventilatory support	1/5 developed pneumothorax.1/4 developed shoulder pain during maximum stimulation, and another had

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			for prolonged time periods. 1/5 had no response to stimulation	intermittent aspiration of food during meals.
DiMarco et al. 2005b	4, ventilator-dependent tetraplegia with unilateral phrenic nerve function	Inspiratory intercostal muscle stimulation combined with phrenic nerve (thoracic) stimulation	4/4 achieved inspired volumes such that they could be maintained off MV between 16 and 24 hours a day.	Stimulation of the upper thoracic region was associated with mild flexion of the hand and upper trunk musculature. 1/4 participants developed symptoms of autonomic dysreflexia with stimulation, 1/4 developed shoulder pain, while another developed an infection at the receiver site.
Onders et al. 2004	28 (mapping group) n = 6 tetraplegia implantation group)	Mapping the phrenic nerve motor point via ES, and laparaoscopic DP	The phrenic nerve motor point was found in 23/28 participants. 5/6 had successful implantation, with three completely free of the ventilator and 2 progressively increasing their time off the ventilator.	One patient had asymptomatic small pneumothorax, and another had a wound infection.
Elefteriades et al. 2002	12, C1/2 - C2 tetraplegia	Bilateral PNS and diaphragm conditioning	Long-term follow up outcomes. 6/12 paced full-time (mean 14.8 years) 1/12 paced full-time for 6.5 years before lapsing to part time	Patients who stopped pacing full-time did so due to inadequate financial or social support, or because they were institutionalized.

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			3/12 paced for an average of 1.8 years before stopping 2/12 were deceased: 1 paced for 10 years.	
Krieger & Krieger 2000	6, C3-C5 tetraplegia	Intercostal to phrenic nerve transfer; PNS	5/6 cases have had longer than 3 months for axonal regeneration. 5/5 regained diaphragmatic motion with phrenic stimulation.	None reported