International Journal of Science and Healthcare Research
[Indexed, Peer-Reviewed Journal]
Vol. 10; Issue: 1; January-March 2025
Website: ijshr.com
Review Article *ISSN: 2455-7587*

Methods for Acute Care Respiratory Rehabilitation of Patients with Spinal Cord Injury: A Brief Review

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DOI: https://doi.org/10.52403/ijshr.20250129

ABSTRACT

Spinal cord injury (SCI) is a traumatic event with an annual incidence of 3.6 - 195.4 patients per million in the world, carries a high risk of morbidity and mortality. Respiratory complications occur in 36-83% of patients with SCI and impaired respiratory muscle function leads to problems such as improper bronchial secretion clearance, pneumonia, atelectasis, and reduced pulmonary functions. A literature search was performed using the following databases: Cochrane Library, PubMed/MEDLINE, EMBASE, CINAHL, and Scopus and various studies were reviewed, which have examined various treatments that affect respiratory functions. Interventions examined include mechanical ventilation, respiratory muscle training (RMT), exercise training, abdominal FES, and treatment strategies for the respiratory management of acute tetraplegia. There is strong evidence to show that non-pharmacological interventions, such as respiratory muscle training (inspiratory and expiratory), have positive effects on lung function in people with acute SCI. Physiotherapy treatments during acute SCI would be useful for stable patients and further prospective large-scale RCTs should continue to be conducted to confirm these findings that physiotherapy is an effective adjuvant to improve acute pulmonary functioning and quality of life in these subjects.

Keywords: Respiratory muscle training, pulmonary functions, tetraplegia, maximum inspiratory pressure.

INTRODUCTION

Spinal cord injury (SCI) is a traumatic event with an annual incidence of 3.6 - 195.4 patients per million in the world, carries a high risk of morbidity and mortality and average annual incidence of SCI in India is 15,000 new cases per year with a prevalence of 0.15 million. Both traumatic and non-traumatic etiologies can result in spinal cord injury, are associated with devastating consequences for the individual and require high economic cost for specialized rehabilitation.[1]

Respiratory complications occur in 36-83% of patients with SCI and impaired respiratory muscle function leads to problems such as improper bronchial secretion clearance, pneumonia, atelectasis, and reduced pulmonary functions. Pneumonia, atelectasis, and respiratory failure are the most common pulmonary complications following SCI which need mechanical ventilation (MV).[2-4]

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Mechanical Ventilation

Spinal cord injury patients can be[5,6] ventilated with non-invasive mask ventilation or with a tracheostomy ventilation. Tracheostomy procedure is required to allow for suctioning excess secretions to prevent the development of complications such as atelectasis or pneumonia. Many modes of ventilation are used for patients that vary in the amount of volume or pressure controlled based on pre-set variables to maximize lung function. As intermittent positive pressure breathing is one of the oldest ventilation strategies in which all inspirations are provided through the application of positive pressure to the airway. Its use is common in patients with SCI, and is not well studied in the SCI population.[7]

Secretion Removal Techniques

A major cause of pulmonary complications in patients with acute SCI results from an inability to clear pulmonary secretions. In cervical spinal cord injuries, there is a dominance of parasympathetic drive that can lead to increased bronchial secretions. Also, nerves that innervate the diaphragm and abdominal muscles may be damaged, leading to impaired coughing ability, or a weaker less effective cough. Mechanical assisted coughing, most given by mechanical insufflation-exsufflation, stimulates coughing. Also, positive expiratory pressure therapy systems are handheld devices used to create pressure in the lungs and help in clearance of secretions.[8]

Respiratory Muscle Training

Acute physiotherapy is a new trend and non-invasive option to help patients resume normal pulmonary functioning and timely discharge. Assisted coughing, intermittent positive pressure breathing, and change in body positioning are some of the techniques used to help keep patients' airways clear. Resistive inspiratory muscle training (RIMT) as well as cough training combined with functional electrical stimulation) are techniques used for physiotherapy in patients with SCI. Inspiratory muscle training[9-11] and respiratory (inspiratory and expiratory) muscle training[12], have been studied in the acute SCI population and are reviewed below (Table 1).

Abdominal Neuromuscular Electrical Stimulation (NMES)

This can be used in combination with voluntary efforts to improve forced expiratory maneuvers including cough. A systematic review showed that abdominal functional electric stimulation is an effective technique for improving respiratory function in people with SCI.[13]

CONCLUSION

Maximum research work done in acute respiratory management for people with SCI is focused on reestablishing ventilation (e.g., tracheostomy, intubation) and preventing and treating respiratory complications. It is of vital importance to maintain an open airway and proper diaphragm functioning while also preventing respiratory failure, atelectasis, and pneumonia. This is an intricate balance as the process of ventilation itself can directly lead to these respiratory complications.

Atelectasis and poor coughing ability are the major cause of pulmonary complications in patients with acute SCI; few high-quality studies show that techniques such as mechanical insufflation/exsufflation facilitate secretion removal in the acute phase of SCI. [14,15]

There is strong evidence to show that non-pharmacological interventions, such as respiratory muscle training (inspiratory and expiratory), have positive effects on lung function in people with acute SCI. [9-12]

Physiotherapy treatments during acute SCI would be useful for stable patients and further prospective large-scale RCTs should continue to be conducted to confirm these findings that physiotherapy is an effective adjuvant to improve acute pulmonary functioning and quality of life in these subjects.

Authors	Title	Design	Characteristics of the participants	Methods	Variables	Results
Derrickson et al., 1992[9]	A comparison of two breathing exercise programs for patients with quadriplegia	Randomized control trial	Age range: 16-41 yr; Level of injury: C4-to C7.	SCI patients were randomly assigned to receive resistive inspiratory muscle training (RIMT) or abdominal weights (AbWts) training for twice daily session, for 5 days a week for 7 weeks.	The following parameters were measured after one week and seven weeks: FVC, IC, maximal voluntary ventilation (MVV), PEF rate, and increased inspiratory mouth pressure (PI max).	Between group comparison revealed no significant differences in all five outcome measures ($p>0.05$). Within group comparison: 2. After 7 weeks, patients who received RIMT training experienced a significantly ($p<0.05$) larger FVC, MVV, IC, PEFR and a lower PImax ($p<0.001$) compared to these measures after 1 week. After 7 weeks, patients who received AbWts training experienced a significantly larger ($p<0.05$) FVC, MVV, PEF and a lower PImax ($p<0.001$) compared to these measures after 1 week.
Liaw et al., 2000[10]	Resistive inspiratory muscle training: its effectiveness in patients with acute complete cervical injury	Randomized control trial	30 participants with SCI (C4-C7, mean age RIMT group :30.9 (11.6) yrs; control group: 36.5(11.5) yrs.	Treatment: Target resistive IMT to RIMT group and conventional treatment to control group;15-20min 2x/day for 6wks; other rehab activities continued.	Measures: Spirometry/ lung function tests, respiratory muscle strength- MIP.	Pre-post % change of VC and TLC in RIMT group was greater compared to change in control group values. MIP improved in both groups.
Postma et al. ,2014[11]	Resistive inspiratory muscle training in people with spinal cord injury during inpatient rehabilitation: A randomized controlled trial.	Randomized control trial	Resistive inspiratory muscle training group: Mean age: 47.1 yr; Level of injury: T12 and above.	Patients were randomly assigned to receive conventional rehabilitation plus RIMT with a threshold trainer (RIMT group); Control group: - conventional rehabilitation care only	Measured following variables: - at baseline, after 8 weeks of intervention, 8 weeks after intervention, 1 yr after discharge: - Respiratory muscle strength (MIP and MEP)- Pulmonary functions (FeV1, FVC, PEFR, and MVV: - FVC, FEV1, peak expiratory flow (PEF) rate, maximum ventilation volume, health-	MIP improved more in the RIMT group compared with the control group 1 week after the intervention period; this difference was no longer significant 8 weeks after the intervention period and at 1 yr after discharge. No other differences were seen in any other parameter. RIMT group improved more in mental health

					related quality of life (HRQoL), and 36-item short-form health survey (SF-36).	compared with the control group 1 week after the intervention period.
Sikka et al, 2021[12]	Effect of 4 weeks resistive inspiratory muscle training on respiratory functions in patients with tetraplegia during in-patient rehabilitation.	Randomized control trial	96 patients enrolled within first week of traumatic cervical SCI; mean age 40.98 years.	Patients were divided to: •RIMT group- given inspiratory and expiratory training with an IMT Threshold trainer for 04 weeks along with conventional treatment. Control Group- given Conventional intervention for 04 weeks.	Respiratory muscle strength (MIP and MEP); Pulmonary function (FeV1, FVC, PEFR, IC, SVC and MVV)	RIMT group as compared to control group, resulted in a highly significant improvement effect on all outcome measures, recorded after 2 and 4 weeks of training ($P < 0.01$).

Declaration by Authors
Ethical Approval: Not required
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Chamatkar Nagar. Methods for acute care respiratory rehabilitation of patients with spinal cord injury: a brief review. *International Journal of Science & Healthcare Research.* 2025; 10(1): 218-222. DOI: *https://doi.org/10.52403/ijshr.20250129*

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