

ACADEMY OF SPINAL CORD INJURY PROFESSIONALS

Effects of Withdrawal and Re-Application of Electrical Stimulation on Expiratory Muscle Function to Restore Cough



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ABSTRACT

Background: Lower thoracic spinal cord stimulation (SCS) has been shown to restore an effective cough mechanism in subjects with spinal cord injury (SCI).

Objective: The purpose of this study was to assess the effects of discontinuation, followed by re-institution, of electrical stimulation of the expiratory muscles via lower thoracic SCS on expiratory muscle function and clinical outcomes.

Design: We evaluated a 57-year-old male subject with SCI (C4, Asia A) who underwent placement of the spinal cord stimulation (SCS) system to restore cough (Cough System). This involved the percutaneous surgical placement of 2 parallel wire leads on the dorsal surface of the spinal cord. Following 2 years of regular use, the system became non-functional. Due to Covid-19 related circumstances revision surgery could not be readily performed resulting in prolonged inactivation of the expiratory muscles for a period of ~2 yrs. Subsequently, the Cough system was replaced. Before and after initial use of the Cough System, following lack of use and again after reinstatement of SCS, measurements of airway pressure generation (P) were made during spontaneous effort and during SCS at functional residual capacity (FRC) and total lung capacity (TLC) to assess expiratory muscle strength. Other clinical assessments included ease in raising secretions, life quality, and incidence of respiratory tract infections.

Results: Prior to the initial implantation, P during spontaneous effort was 22 cmH₂O. Following a re-conditioning phase, SCS at FRC and TLC, resulted in P of 70 and 103 cmH₂O, respectively. After prolonged complete inactivation, P during spontaneous efforts fell to 12 cmH₂O. Following revision surgery, SCS at FRC and TLC, again resulted and increase in P to 78 and 98 cmH₂O, respectively. Following each instance of SCS to restore cough, there were also significant improvements in each of the measures related to airway clearance including easing in raising secretions, reduction in the severity of cough episodes and lack of need for other methods of secretion management. Moreover, after the initial and subsequent use of the Cough System, the incidence of acute respiratory tract infections fell from 3.0 to 0.5 and 4.5 to no events/subject year, respectively

Conclusion: Following prolonged inactivation, the force generating capacity of the expiratory muscles is markedly reduced secondary to disuse atrophy. SCS results in restoration of expiratory muscle function and associated physiologic and clinical benefits of restoration of an effective cough. Discontinuation of SCS results in the re-development of marked atrophy which can again be reversed with the re-application of SCS. As with other skeletal muscles, the expiratory muscles manifest a high degree of pliability with regard to the effects of electrical stimulation.

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INTRODUCTION

Patients who lack an effective cough may experience significant physical discomfort including difficulty clearing secretions and the sensation of choking and, medical complications including a higher risk of aspiration and the development of respiratory tract infections. In fact, patients with SCI are ~150 times more likely to die from pneumonia compared to the general population. Lower thoracic spinal cord stimulation (SCS) is a useful method to restore an effective cough (Cough System) in subjects with cervical spinal cord injury (SCI). This device involves the minimally invasive placement of wire electrodes on the dorsal epidural surface of the spinal cord at the T9 and T11 levels. In this report, we benefits of using the Cough System, the effects of discontinuation of the Cough System for ~ 2 years an, the effects of re-institution of this modality.

METHODS

Participant: The participant is a 57-year-old male who suffered a cervical spinal cord injury (C4, ASIA A) who initially underwent placement of the Cough System and benefitted from this modality. However, the device became non-functional and due to Covid-19 related circumstances revision surgery could not be timely performed resulting in prolonged inactivation of the expiratory muscles for ~2yrs. The Cough System was then re-implanted and the effects of use of this device were re-evaluated.

Surgical Procedures:

- Insertion of wire leads (Ardiem Medical, Inc.) on the dorsal epidural surface of the spinal cord
- Electrode position confirmed by fluoroscopy
- Placement of radiofrequency receiver (Finetech Medical Ltd, England) subcutaneously

Outcome Measures: The objective parameters of expiratory muscle strength (airway pressure (P) and peak expiratory airflow (F) and clinical effects (difficulty raising secretions and incidence of respiratory tract infections) were evaluated a) initially, b) after placement of the Cough System, c) prior to replacement of the system and d) again after replacement of the system

Data Analysis: Maximum P and F, and clinical outcome parameters at each stage mentioned above were analyzed. Statistical analysis using a repeated measures analysis of variance and student's t test (p<0.05, taken as significant). Results are presented as means ± SE.

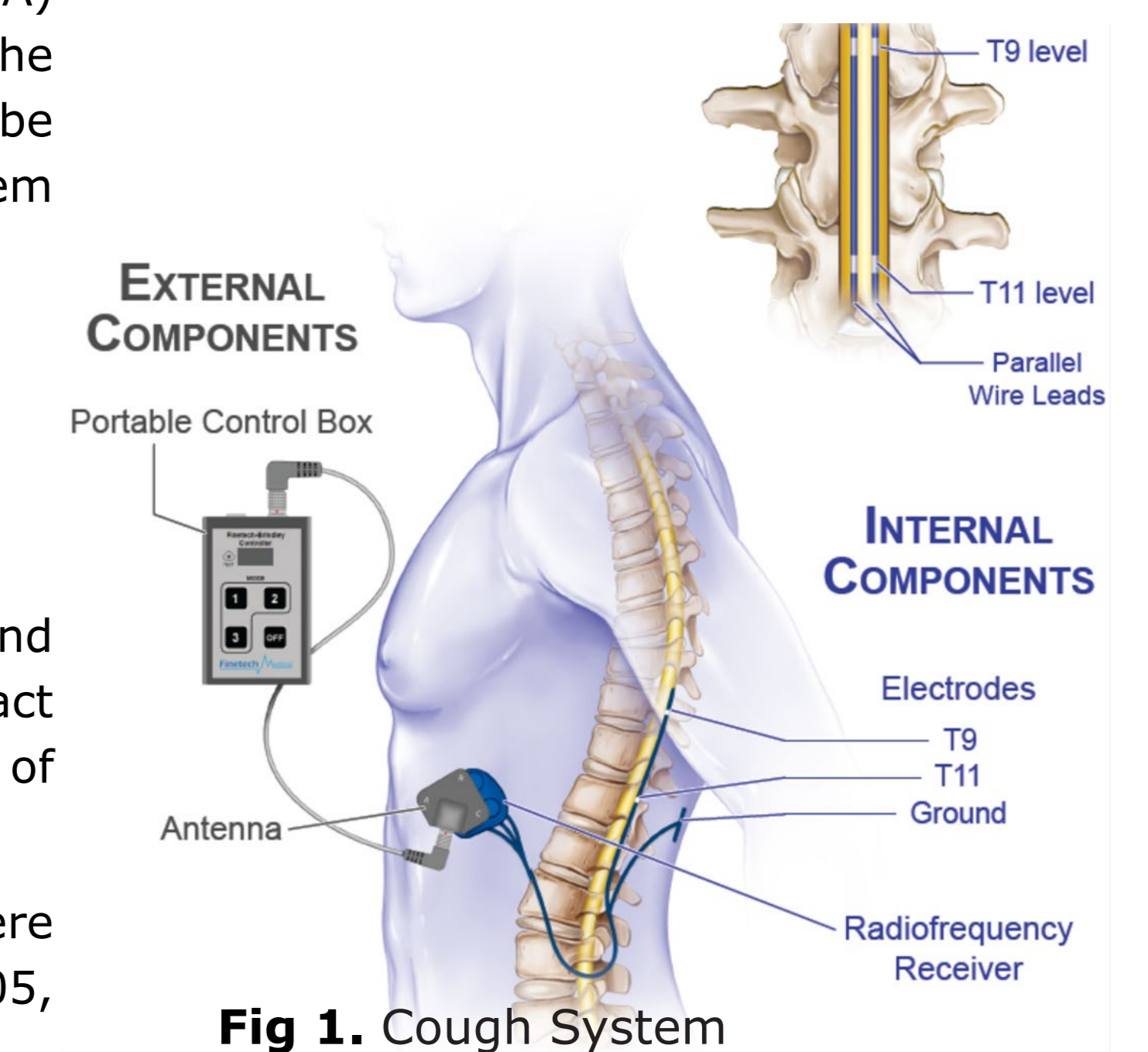


Fig 1. Cough System

RESULTS

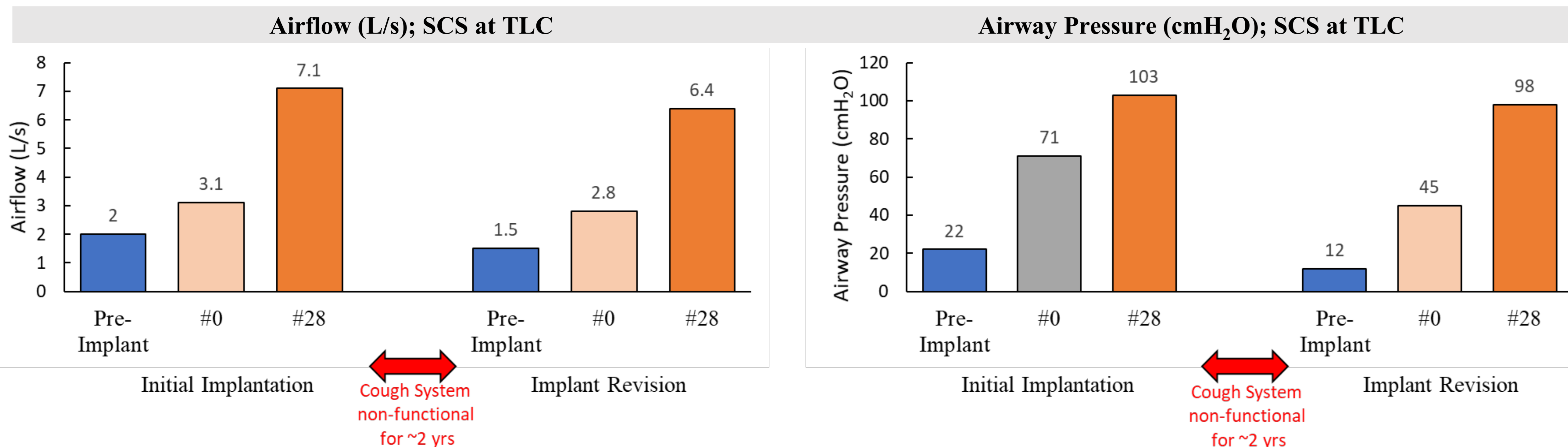


Fig 2. Mean peak airflow rates (left panel) and mean airway pressures (right panel) during SCS at TLC prior to and after initial use of the Cough System and, again prior to and after revision surgery following ~2yrs. of inactivity of the System.

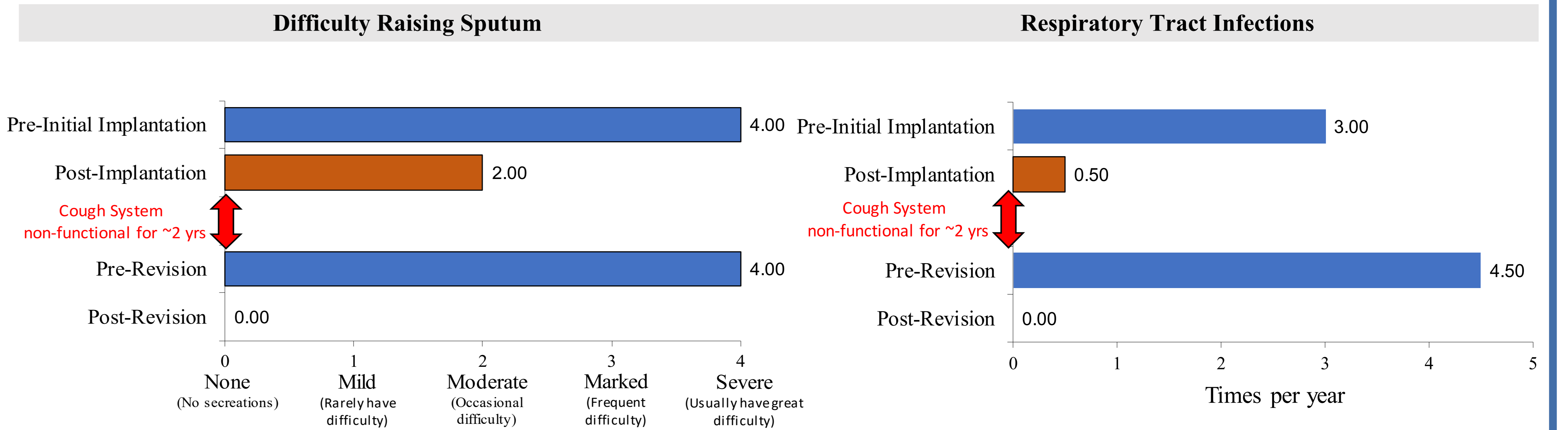


Fig 3. Main Clinical Outcome Measures: Ease in raising secretions (left panel) and incidence of acute respiratory tract infections (right panel).

SUMMARY AND CONCLUSION

Discontinuation of SCS results in the re-development of marked atrophy and significant respiratory related complications which can again be reversed with the re-application of the Cough System.