Association of Calcium and Vitamin D Supplements with Fractures in Persons with a Traumatic SCI

Abstract 248
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Background: Fractures are prevalent in persons with a spinal cord injury (SCI) and are associated with significant morbidity and mortality. In 2022, the Paralyzed Veterans of America (PVA) convened to develop a guideline for managing osteoporosis in SCI. The PVA recommended calcium and vitamin D supplementation to support skeletal health; however, the PVA acknowledged its position was largely informed by reports from able-bodied persons due to lack of SCI-specific data. The objective was to determine the association of calcium and vitamin D supplementation with fracture risk in Veterans with a SCI.

Methods: We included Veterans with a chronic (> 2 years), traumatic SCI in the Veterans Health Administration Spinal Cord Injuries & Disorders Registry at the start of Fiscal Year (FY) 2014 and followed them from FY2014-FY2020. Outcome was an incident fracture defined as an ICD-9 or ICD-10 code for an upper or lower extremity fracture. Filled prescriptions for calcium and vitamin D were obtained from outpatient pharmacy data. Only those with at least 6 months of continuous filled scripts at an adherence level of at least 80% were considered as having had their calcium or vitamin D supplemented. For calcium, dose subgroups of (i.) > 0 mg to 500 mg, (ii.) > 500 mg to 1000 mg, or (iii.) > 1000 mg/day were compared to the referent category. For vitamin D, dose subgroups of (i.) > 0 IU to < 2000 IU, (ii.) < 2000 IU to < 4000 IU and (iii.) > 4000 IU/day were compared to the referent category. The referent category included those with no filled prescriptions or filled prescriptions for less than 6 months at an adherence level of less than 80%. Cox proportional hazards regression multivariate analysis was performed. Covariates included were demographics, SCI-related data, Charlson Comorbidity Index, prior fracture, and use of anticonvulsants, benzodiazepines, opioids, sedatives/hypnotics, corticosteroids, antidepressants, and thiazides.

Results: There were 5,897 Veterans with chronic, traumatic SCI. 765 patients had calcium supplements (13%); 2,295 patients, vitamin D supplements (38.9%). 21% of Veterans (n=1240) had a fracture. Comparing the referent group to all other calcium subgroups, calcium supplements were associated with a decreased risk for fracture (HR 0.65, 95% CI (0.54-0.78)). Specifically, doses of >0 mg to 500 mg/day were associated with a decreased risk compared to the referent category (HR 0.59, 95% CI (0.48-0.73)), but no significant associations existed between doses of >500 mg to 1000 mg/day (HR 0.93, 95% CI (0.62-1.38)) and >1000 mg/day (HR 1.10, 95% CI (0.35-3.44)). Comparing the referent group to all other vitamin D subgroups, vitamin D supplements were associated with a decreased risk for fracture (HR 0.59, 95% CI (0.48-0.73)), but no significant associations existed between doses of > 0 IU to 2000 IU was associated with a 3-fold decreased risk for fracture compared to not being on any vitamin D (HR 0.33, 95% CI (0.29-0.38), P<0.001). Vitamin D at doses of <2000 IU and <4000 IU were also associated with a 3-fold decreased risk for fracture (HR 0.32, 95% CI (0.20-0.50)).

Conclusions: Calcium and vitamin D supplements are associated with decreased risk of fracture, supporting PVA guidelines that calcium and vitamin D intake are important for skeletal health in persons with a SCI.

**Learning Objective 1** Discuss the importance of fracture prevention in persons with a SCI

**Learning Objective 2** Discuss current recommendations for calcium and vitamin D supplementation in persons with a SCI

**Learning Objective 3** Describe how calcium and vitamin D supplementation is associated fracture risk in persons with a SCI
Factors Influencing Standing and Walking Outcomes during Inpatient Rehabilitation in Persons with Traumatic Spinal Cord Injury: a Canadian perspective

Abstract 42
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Objective: Walking is an important goal for people following incomplete SCI. Rehabilitation approaches to walking vary between therapists and centers. It is not clear what factors or rehabilitation approaches lead to optimal standing and walking outcomes. The SCI Standing and Walking Assessment Tool (SWAT), combines 12 stages of function with measures of balance and walking to provide a standardized assessment during inpatient rehabilitation. We examined the relationship of individual, practice, and system level factors on SWAT stage change and explored therapists’ perspectives to identify components related to improved SWAT outcomes.

Design/Methods: 3-phased mixed methods approach: (1) Rick Hansen Spinal Cord Injury Registry (RHSCIR) retrospective analysis (2014-2022). 1552 participants with traumatic SCI from 11 Canadian SWAT centers were included. Bivariate and multivariate analyses were performed to identify factors associated with SWAT stage change between admission and discharge. (2) Online survey completed by 27 SWAT center physiotherapists to: identify factors applicable to their practice (e.g. therapeutic approach, etc.), rank applicable factors in relation to positive standing and walking outcomes, and rank all factors in relation to positive outcomes. Findings summarized with descriptive statistics. (3) Qualitative focus groups with 10 physiotherapists from 7 SWAT centers to obtain perspectives on current practices and gain insights into center-specific factors that may influence standing and walking outcomes. Reflective thematic analysis was used.

Results: (1) RHSCIR analysis – Bivariate analysis showed significant differences in age, number of comorbidities, mechanism of injury, neurology, lower extremity motor score (LEMS), rehabilitation onset (days from injury to admission), and center. Adjusting for these, multivariate analysis identified SWAT stage change significantly differed with neurology, rehab Length of stay (LoS), rehab onset, and center (p<0.0001). Parameter estimates from the negative binomial regression signified that with other model variables constant, a SWAT stage change of 3 at center A would be 4.8 at center B. (2) Survey – Positive factors included activity-based and task-oriented therapeutic approaches that emphasize intensity and academic partnerships that enable access to specialized equipment or research participation. Positive factors that were deemed inaccessible by a many therapists included positive work culture, bodyweight supported treadmill training, and opportunities for conference participation. (3) Focus groups – Key factors identified were LoS, equipment availability, high treatment intensity and frequency. Other important factors were building rapport with patients, therapeutic environment, and having sufficient staffing available.

Conclusion: RHSCIR analysis found individual factors (neurology), system factors (LoS, rehab onset) and therapeutic or environmental factors (center) were significantly related to SWAT stage change during inpatient rehabilitation. While individual and system factors align with previous research, our results highlight specific therapeutic and environmental factors to be considered in order to identify, evaluate, and share ways to improve standing and walking outcomes.

Learning Objective 1 Describe the Standing and Walking Assessment Tool

Learning Objective 2 Recognize factors that influence standing and walking outcomes during inpatient rehabilitation in persons with traumatic SCI

Learning Objective 3 Identify areas for potential improvement in standing and walking outcomes
Home-based ARC-EX Therapy Transcutaneous Spinal Cord Stimulation Safely Maintains and Extends Upper Extremity Functional Recovery following Spinal Cord Injury: Results from the LIFT Home Trial

Abstract 170
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Objective: ARC-EX Therapy, which combines transcutaneous spinal cord stimulation with functional task practice, significantly improves hand and arm function following cervical spinal cord injury (SCI)1-3. However, individuals with SCI often face numerous socioeconomic barriers limiting the continuation of in-clinic therapy. These include limited insurance coverage, significant out-of-pocket costs, transportation challenges, and difficulty accessing specialized therapy facilities. To address these barriers, the LIFT Home Trial (NCT05284201) evaluated the safety, feasibility, and effectiveness of ARC-EX Therapy in the home setting.

Methods: Seventeen individuals with incomplete, chronic cervical SCI who had participated in the clinic-based Up-LIFT Trial within the prior 12 months were enrolled in the trial. Participants completed a one-month home-based therapy program, with the aid of a caregiver. ARC-EX Therapy was tailored to their activities of daily living within their home environment. Safety outcomes included all occurrences of adverse events. Adherence to the prescribed therapy program, as well as device usability and utilization practices were used to assess the feasibility of home-based therapy. Efficacy outcomes assessing sensorimotor improvements over the 1-month period included the Capabilities of Upper Extremity Test (CUE-T), the Graded Redefined Assessment of Strength, Sensation and Performance (GRASSP), pinch and grasp forces, and global impression of change scores. Additional post-hoc analysis examined the potential of home-based therapy to maintain or extend improvements achieved in-clinic during the Up-LIFT trial. Finally, multiple measures of quality of life and independence were assessed via participant-reported surveys.

Results: There were no reported adverse events related to device use in the home environment. Compliance with the prescribed therapy was high and mirrored in-clinic therapy dosages, with participants completing 12.3 ± 2.9 sessions each lasting 59 ± 10 minutes on average over the one-month period. Participants chose to remain within 1% of the clinician-programmed amplitudes, and only one individual required an in-person visit for assistance, indicating a highly successful transition to home-based therapy. Within the month-long trial, average CUE-T scores and pinch forces significantly improved (Δ 2.2 ± 4.1, p=0.025 and Δ 6.9N ± 15.5, p=0.020, respectively), as did pain interference with day-to-day activities (ISCPID subscore Δ -0.6 ± 1.2, p=0.019), psychological health (WHOQoL-BREF subscore Δ 3.4 ± 5.8, p=0.025), and self-care ability (SCIM III subscore Δ 0.2 ± 0.4, p=0.042).

Conclusions: Home-based delivery of ARC-EX Therapy was found to be safe, feasible, and effective. The LIFT Home Trial provides evidence that supports the maintenance and further enhancement of in-clinic benefits when this therapy is translated to the home environment. Support: The LIFT Home Trial was sponsored by ONWARD Medical.

Learning Objective 1 Discuss the safety and feasibility of ARC-EX Therapy in the home setting.

Learning Objective 2 Evaluate the benefits of continued ARC-EX Therapy beyond initial in-clinic rehabilitation on upper extremity sensorimotor function.

Learning Objective 3 Discuss how home-based ARC-EX Therapy might reduce barriers to treatment and improve quality of life for individuals living with SCI.
The Role of Diaphragm Pacing in Pediatric Spinal Cord Injury: Decreasing Invasive Mechanical Ventilation

Abstract 152
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Introduction: Pediatric spinal cord injury (SCI) is rare and comprises <10% of all SCI in the United States. There is just under 1500 new cases yearly. However, pediatric injuries have a disproportionate association of cervical injuries. The higher the level of injury the more likely the need for tracheostomy mechanical ventilation (TMV), which is associated with significant morbidity and mortality. Diaphragm Pacing (DP) can replace or decrease the amount of TMV. This report focuses on pediatric population who had traumatic spinal cord injuries. Methods: This is a retrospective review of all prospective IRB DP databases at a single institution. All patients had preoperative evaluation and then underwent laparoscopy for diaphragm pacing. Results: From January 2000 to July 2023 nearly 800 patients were implanted with DP. There has been 42 pediatric patients (age 0 to 18 years) implanted with DP from 2009 to 2023; 17 met the criteria of ventilator dependent traumatic SCI. The ages ranged from 1 years to 17 years with an average of 9.4 years. Five are female. The weights ranged from 8 kg to 81 kg (average 36.7, median 27.5). Injuries generally involved multiple levels with the highest level of injury as follows: 8 had C1 involvement, 7 had C2, and 2 had C4 involvement. Fifteen patients were in MVC and 2 were injured from sports. Time on mechanical ventilation prior to DP ranged from 7 days to 7.6 years with average time of 31.4 months and median time of 15 months. Twelve patients went to the OR with a feeding tube present and 5 had feeding tubes placed with DP. Two patients had baclofen pumps and 1 patient had a VP shunt. One patient had a cardiac pacemaker. Four patients had at least 1 hemidiaphragm documented as weak at the time of implant. Once implanted, diaphragm electromyography (dEMG) was measured through the electrodes and only 3 patients had some measurable EMG activity of the diaphragm. Ten (59%) patients were able to replace MV with pacing full time. Three patients are between 12 and 16 hours and one patient does 3-4 hours daily. Three patients, all with weak diaphragms at surgery, never achieved greater than 2 consecutive hours. Four patients, one with very weak diaphragms, regained automatic breathing. Pacing was weaned and electrodes removed. Three patients had tracheostomies decannulated and 1 patient avoided tracheostomy. There is an average of 91.4 months (4 to175 months) of continuous electrode use. Six have been pacing between 9 and 14 years. There are 2 deaths; not respiratory related and 2 patients lost to follow up. Conclusion: A great percentage of patients were able to replace MV full or nearly full time with DP. There have been no complications to long-term full-time use. There were no peri-operative complications. Using dEMG, we showed DP aided in the recovery of spontaneous ventilation. DP allowed a decrease tracheostomy usage. There is significant long-term survival among this group. Given these results, DP should be used routinely in the pediatric spinal cord injured population.

Learning Objective 1 Discuss the complications of ventilator dependence in pediatric spinal cord injury

Learning Objective 2 Analyze the ability to wean from mechanical ventilation with diaphragm pacing

Learning Objective 3 Discuss current management of diaphragm pacing in spinal cord injury

Abstract 267
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Objectives: A superimposed traumatic brain injury (TBI) is often seen in patients with acute traumatic spinal cord injury (TSCI). Unfortunately, due to methodological limitations of previous studies, the exact epidemiology of concomitant TBI-TSCI remains unknown. Accordingly, the objective of this study is to determine the incidence of concomitant TBI-TSCI and identify clinical factors associated with its development. Methods: A prospective cross-sectional study of 476 TSCI patients at the time of admission to a single Level-1 trauma center in Montreal, Canada, was conducted. In all patients, the presence of a TBI was sought prospectively by a specialized neurosurgeon using standardized diagnostic criteria based on clinical and radiological variables. Baseline characteristics were compared between patients who were diagnosed with concomitant TBI and patients who were not. Multivariate analyses were finally performed to identify factors independently associated with concomitant TBI-TSCI. Results: Out of the 476 included patients, 250 (53%) had isolated TSCI and 226 (47%) had concomitant TBI-TSCI. Almost 85% of diagnosed TBI were mild. At the univariate level, patients with concomitant TBI-TSCI were more likely to present a history of drug or alcohol abuse (p=0.014), be involved in a motor vehicle accident (p<0.001), sustain a high energy mechanism of injury (p<0.001) or tetraplegia rather than paraplegia (p=0.021). These factors all remained significant at the multivariate level. At this stage, older age was also associated with increased odds of sustaining a TBI. Discussion: A superimposed TBI can be found in around 50% of TSCI individuals. There are several clinical variables that should increase clinical suspicion of underlying TBI and warrant further investigation to facilitate prompt identification and treatment of affected patients.

Learning Objective 1 Review the incidence of concomitant TBI in SCI patients

Learning Objective 2 Discuss potential risk factors for occurrence of concomitant TBI

Learning Objective 3 Suggest clinical cues for clinicians suspecting concomitant TBI