Constraint-Induced Movement Therapy to Improve Paretic Upper-Extremity Motor Skills and Function of a Patient in the Subacute Stage of Stroke

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Upper-extremity (UE) dysfunction is common after stroke. Four out of five people with stroke initially present with hemiparesis of the affected UE.[1] Of those with significant impairment at onset (~30%), over 80% will demonstrate persistent functional deficits at 6 months post-stroke.[2] These findings strongly support the notion that more effective therapeutic interventions for the paretic UE are needed. This article examines the potential role of constraint-induced movement therapy (CIMT) as a strategy to improve motor skills and function of the paretic UE of a patient undergoing stroke rehabilitation.

CLINICAL QUESTION

Is CIMT an appropriate intervention to improve paretic UE motor skills and function of a patient in the subacute stage post-stroke?

CLINICAL CASE

PF is a 60-year-old, college-educated safety officer in a manufacturing facility who lives in a suburban two-storey townhouse with his spouse. His interests include watching racecar driving and stamp collecting, and he has a 6-month-old grandson. Before his stroke, PF was healthy apart from hypertension, which was controlled with medication. While at work, PF experienced acute weakness in his right arm and leg; the local emergency department diagnosed an ischemic stroke on the left side of the brain stem. PF spent 1 month in an acute-care facility receiving medical care and early post-stroke rehabilitation, and was then transferred to a rehabilitation centre.

PF's pharmacological therapy included an antiplatelet drug to inhibit further blood clotting, a diuretic drug and an angiotensin-converting-enzyme inhibitor (ACE-inhibitor) drug for hypertension. On baseline assessment, his right grip strength (Jamar Hydraulic Hand Dynamometer; Sammons Preston Patterson Medical Products, Inc., Bolingbrook, IL, USA) was 16.7 kg, right UE Modified Ashworth Scale scores were 0 throughout, and Chedoke-McMaster Assessment of Shoulder Pain was Stage 7. The Chedoke-McMaster Stroke Assessment (CMSA) indicated Stage 4 recovery of both arm and hand. PF had intact sensation and communication and showed 25° of active range of motion (AROM) into right wrist extension and 10° AROM into metacarpophalangeal and interphalangeal extension of all digits (measured from a flexed position). He transferred 25 blocks in 1 minute on the Box and Blocks Test (BBT), required 60.0 seconds to complete the 9-Hole Peg Test (9HPT), and scored 36/91 on the Chedoke Arm and Hand Activity Inventory (CAHAI). Given PF's physical findings, we decided to consider CIMT as a possible intervention to improve PF's UE motor skills and function.

THE EVIDENCE

Support for CIMT as an UE intervention post-stroke

A relatively new therapeutic intervention for UE rehabilitation after stroke, CIMT originally derives from animal studies performed by Taub and colleagues.[3] The CIMT protocol consists of a 2-week training period with three components: (i) restraint of the less-affected UE (e.g.,

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sling or mitt) for 90% of waking hours; (ii) intense repetitive practice of functionally relevant tasks with the paretic UE for 6 hours/day; and (iii) behavioural techniques designed to ensure that the skills gained from CIMT are transferred to real-life situations.[4] Training tasks (e.g., writing, grasping objects and using utensils) are chosen based on specific joint movements with the greatest deficits, movements with the greatest potential for improvement and the degree to which the patient values the task.[5] Behavioural techniques include ''shaping'' or progressing motor and behavioural tasks in incrementally more difficult steps and providing immediate feedback with enthusiastic approval of success, but never condemnation of failure.[3] Other behavioural strategies include prescribing homework exercises, signing a behavioural contract, scheduling problem-solving sessions to help overcome barriers to daily use of the affected UE, and keeping a diary of the restraint time, treatment and homework.[6]

Several studies have investigated the efficacy of CIMT in improving paretic UE function after stroke. The largest study was a multi-centre, single-blinded randomized controlled trial (RCT), the EXCITE trial, that compared CIMT to usual post-stroke rehabilitation.[6] The main finding was that CIMT was superior to usual care in improving function, amount of use and quality of movement in the paretic UE.[6] However, a retrospective analysis of the data found no relationship between intensity of training and outcomes among participants who showed statistical and clinical improvements.[7] The authors concluded that functional improvements may be attributable to the ratio of training components (shaping and repetitive task training) and not to training intensity.[7]

Other studies have questioned the significance of other components of CIMT. An RCT comparing the effects of restraint versus no restraint during CIMT in subacute stroke found no effect of restraining the less affected hand.[8] In another study, Uswatte and colleagues concluded that neither the type of training (task training, shaping) nor the type of restraint (sling, half-glove, no restraint) appeared to be a critical factor in immediate treatment outcomes.[4] Although it remains unclear which component, if any, is the critical element for the efficacy of CIMT, two systematic reviews have concluded that CIMT in general is associated with reduced disability post-treatment[9] and with improved mobility of the paretic UE (e.g., carrying and handling objects).[10]

Rationale for prescribing CIMT for PF

Despite the demanding treatment time and resource use associated with the original CIMT protocol described above, we have deemed the delivery of the treatment to be feasible in PF's health care setting (in-patient rehabilitation centre). Moreover, PF expressed a preference for an intervention that was more intense and shorter in duration than alternative approaches to UE rehabilitation, including modified forms of CIMT.[9,10]

To determine whether CIMT was indicated in PF's case, we considered his clinical presentation in light of the existing evidence on CIMT. With respect to *time since onset of stroke*, evidence suggests that non-pharmacological interventions yield maximum benefit during the early stages of stroke recovery.[11] In the case of CIMT specifically, a trial involving people 2–12 weeks post-stroke found that UE function improved more with CIMT than with dose-matched usual care.[12] Nonetheless, Brunner and colleagues recommended postponing implementation of CIMT until 1 month after stroke because substantial improvement in UE function occurs in response to standard rehabilitation within the first month.[13] At 4 weeks post-stroke, therefore, PF seemed well positioned to benefit from CIMT.

The *motor criteria* for the clinical application of CIMT are (i) $\geq 20^\circ$ of active wrist extension and (ii) $\geq 10^\circ$ of active extension of each metacarpophalangeal and interphalangeal joint of all digits.[6,14] PF's baseline AROM exceeded these criteria. Evidence from several CIMT studies indicates that clinically important improvements can be expected in people with moderate motor and functional impairment at baseline.[6,15–17] PF demonstrated moderate impairment of his paretic UE, reflected in low performance relative to age- and sex-matched normative values on grip strength (approximately 40% of normative value),[18] BBT (about one-third of the expected value),[19] and 9HPT (three times the duration expected of a non-disabled 60-year-old man).[20] Similarly, his CAHAI score of 36/91 indicated moderate functional disability.[21] PF also demonstrated intact cognition, which has been used as an inclusion criterion for participation in several CIMT trials and was shown to be beneficial in optimizing therapeutic outcomes.[4–6,13,16]

Expected outcomes of a CIMT programme for PF

Findings of CIMT studies suggest that PF will respond positively to a trial of CIMT. Prior studies have reported significant CIMT-induced improvements in grip strength (mean improvement of 9.9 kg,[22] almost twice the minimal clinically important difference of 5.0 kg for people in the subacute phase of stroke).[23] Studies have also documented improved manual dexterity (as measured by the 9HPT) following CIMT;[12,17] for example, Rijntjes and colleagues reported a 45% improvement in 9HPT performance after CIMT.[17] Furthermore, McCall and colleagues found that, in people with subacute stroke, a modified form of CIMT led to clinically meaningful changes in CAHAI score (i.e., a mean change score >6.3 as determined by Barreca and colleagues[21]).[24] One participant in their study who presented with CAHAI and CMSA baseline scores similar to those of PF, achieved a change in score of 12.8 points on the CAHAI.[24]

Based on PF's initial presentation and existing evidence, we are guardedly optimistic that PF can achieve better function and more spontaneous use of his paretic UE. The fact that PF does not have shoulder pain is an asset, as shoulder pain has been shown to hinder recovery after stroke.[25] His lack of hypertonia is also an advantage, since spasticity has been reported to interfere with the smoothness and execution of the task-oriented training component.[17]

For a successful outcome, it will be critical to develop a CIMT programme with tasks adapted to PF's motor capabilities and interests to stimulate the motor relearning processes.[26] Capitalizing on his interests in racecar driving and stamp collecting, as well as on his new role as a grandfather, could be helpful in personalizing the therapy sessions to optimize both adherence and response.

CONCLUSION

The Canadian Best Practice Recommendations for Stroke Care endorse CIMT as a treatment to enhance UE recovery post-stroke.[27] Given the level of existing evidence to support CIMT, as well as PF's clinical presentation—4 weeks since stroke onset, AROM exceeding the minimum criteria for CIMT, intact cognition and moderate motor impairment and functional disability of his paretic UE—a trial of CIMT is justified.

FUTURE RESEARCH

Although the effectiveness of CIMT in improving UE function post-stroke is relatively well established, it remains unclear which of the three components of CIMT are essential for optimal outcomes. Identifying the critical component(s) would allow streamlining of the intervention to enhance its clinical feasibility and utility in terms of time and resources.

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