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Neurorehabilitation for Pancerebellar Ataxia with Pyramidal Tract Dysfunction: A 6-Week Protocol for Improving Balance and Coordination - A Case Study

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ABSTRACT

Pancerebellar ataxia combined with pyramidal tract dysfunction is a neurological syndrome causes complex motor deficits such as postural instability, gait disruption, and decreased coordination, all of which greatly limit functional independence. There is minimal evidence to support systematic physiotherapy therapies for this combined neurological involvement, particularly in chronic patients.

This case study presents a 38-year-old female diagnosed with a rare form of pancerebellar ataxia with pyramidal tract involvement, with progressive difficulties in gait, balance, coordination, frequent fear of falls, oculomotor disorders and dizziness, which hamper her activities of daily living.

A tailored physiotherapy protocol was implemented over a period of 6 weeks, with the primary aim of improving balance and coordination, which consist of trunk and limb strengthening, progressive balance training, task-specific coordination exercises, gait training, and vestibular exercises. The intervention was delivered five six sessions per week, with progression based on patient performance and tolerance. Outcome measures included the Berg Balance Scale (BBS)and the International Cooperative Ataxia Rating Scale (ICARS), reassessed with 2-week intervals for 6 weeks. Significant improvement in scores was evident post-intervention, indicating a decrease in severity of ataxia.

The effects of this case study demonstrate the efficacy of physiotherapeutic intervention in treating complex neurological diseases affecting both the cerebellar and pyramidal tracts. The results suggest the potential importance of focused neurorehabilitation techniques and call for more research through bigger clinical studies, even though findings from a single patient cannot be generalised.

Keywords: Pancerebellar Ataxia, Pyramidal Tract Dysfunction, Balance, Incoordination, Gait training, Berg Balance scale, Neurorehabilitation.

INTRODUCTION

Pancerebellar ataxia is a neurological syndrome characterized by widespread cerebellar dysfunction, presenting clinically with gait and limb ataxia, dysarthria, and oculomotor anomalies. A variety of underlying etiologies, including genetic disorders, autoimmune conditions, and paraneoplastic syndromes, may contribute to the development of this condition[1].

Cerebellar dysfunction may involve the entire cerebellum or may be localized to specific regions, resulting in distinct clinical presentations. Two primary cerebellar syndromes are recognized: vermis (midline) syndrome and hemisphere (lateral) syndrome[2]. Vermis syndrome predominantly affects posture and gait, with symptoms ranging from mild gait ataxia to profound balance impairment and ambulatory difficulty. In contrast, cerebellar hemisphere dysfunction typically leads to appendicular ataxia, characterised by incoordination of the ipsilateral limbs, particularly affecting upper extremity movements[2].

The estimated prevalence of cerebellar ataxias in India ranges from 4.8 to 13.8 per 100,000[3]. According to a study, midline syndrome is the most frequent dominant ataxia in Gujarat [4]. As a result, there are a limited studies that document physiotherapeutic intervention in rare ataxic syndrome with involvement of the pyramidal tract, making this case study a significant contribution to the existing literature. This case study aims to emphasise the clinical presentation and physiotherapeutic interventions associated with balance and incoordination.

PATIENT INFORMATION

38-year-old female patient came to the physiotherapy outpatient department with the chief complain of difficulties in walking and keeping a standing position requires assistance after some time and had slowness of movement while doing activities of daily living. patient had difficulty in judging the distance to do fine coordinated skill movements, intentional tremors were present while doing any household activity. Additionally, the patient complains of dizziness while waking up from the bed, during quick turns of head to one side, abrupt turns, or responds to a call from behind and during transition from supine to sit. Patient was diagnosed with Chronic Pancerebellar Ataxia with pyramidal tract involvement confirmed by consulting neurologist. Informed consent was taken from the patient to conduct case study.

CLINICAL FINDINGS

On MRI investigation patient had mild cerebellar atrophy, changes in the pyramidal tract were found (shown in figure 1 and 2), with positive pathological reflex like Babinski reflex and upper motor lesion symptoms like hyperreflexia, hypertonicity (spasticity), muscular weakness, along with cerebellar ataxia symptoms like tremors, imbalance, trunk instability, gait abnormalities, incoordination, dysmetria, dysdiadochokinesia, nystagmus, with vestibular involvement were also found.

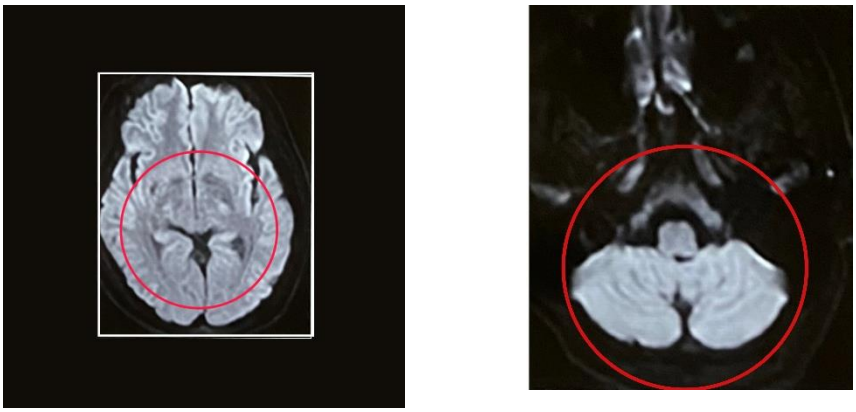

Figure 1 suggests changes along the pyramidal tract suggestive of upper motor neuron involvement.
Figure 2 suggests cerebellar atrophy mild cerebellar atrophy consistent with pancerebellar involvement.

ASSESSMENT AND DIAGNOSIS

History

The patient has a positive family history of ataxia, medical history of hyperthyroidism, Vitamin E and B12 deficiency.

MOTOR EXAMINATION

Reflexes

The patient had a positive pathological Babinski reflex on her left foot with altered superficial reflexes, like abdominal reflex and plantar reflex.

On deep tendon reflex examination exaggerated reflex of bicep jerk and tricep jerk with pendular knee jerk and a brisk ankle reflex on the left side of the body were present.

Tone assessment

In tone assessment the patient had hypertonicity on the left side which was measured according to modified Ashworth scale[5]

Table 1: Abnormal Tone assessment according to modified Ashworth scale

Muscle		Grades of abnormal tone according to modified Ashworth scale
Upper limb	Biceps	1
Lower limb	Quadriceps	1+

Muscle Tightness

Shortness of the triceps muscle checked by triceps tightness test[6] and tightness of hamstring were measured by taking 90-90 straight leg raising test [6] and piriformis test6 for piriformis muscle were conducted to detect tightness.

For trunk stability, manual muscle strength[6] was taken for trunk flexors and extensors, which was grade 2 in the patient

Coordination Assessment

For assessing the ataxia-related symptoms both the coordination test which were equilibrium and non-equilibrium test were conducted to assess the following:

Dysmetria: The patient is instructed to contact the therapist's finger, then repeat the maneuver from the patient's nose to the therapist's finger, alternating between the two[7]. The patient tested positive for dysmetria. The patient was also tested with finger-to-finger, past-pointing, and heel-to-shin exercises, all of which she was unable to complete.

Dysdiadochokinesia: Its incapacity to execute quick alternate motions was demonstrated by asking the patient to quickly supinate and pronate their forearm[7]; nevertheless, the patient stopped because of their excessive slowness and lack of coordination.

Tremors were assessed by asking the patient to draw Archimedean's spirals [8] which was unable to completed by the patient.

Balance was assessed by taking Romberg's test[7] which was positive with marked increased anterior posterior sways.

Dizziness

To assess dizziness the Hall pix dix test[7] was done on the patient for anterior-posterior semicircular canal involvement, the left side symptoms were more severe than the right side, and there was evident nystagmus was found.

Gait examination

On gait observation[7], there was "Drunken gait" (ataxic gait) pattern observed in patient, where patient walks with a wide base of support. there is an alteration in the stance phase, absence of heel strike and direct foot flat to toe off was observed. with the decrease in swing phase in gait cycle of the patient, cadence was decreased, with an increase in step length, step width with marked trunkal sway and increased arm swing.

OUTCOME MEASURE

1) The International Cooperative Ataxia Rating Scale (ICARS)[9] It is a 100-point scale consist of 19 items with 4 subscales: 1) Posture and Gait Disturbance 2) Kinetic Function 3) Speech Disorder 4) Oculomotor Disorders (Reliability 0.95 validity 0.72) 9 this scale was taken out of which patient scored 40/100.
2) Berg Balance scale[10] it is a 14-item objective measure that assesses balance Items include static and dynamic activities with varying degrees of difficulty.

Item-level scores range from 0-4, determining the ability to do the examined activity. Maximum score 56. (Reliability 0.98 validity 0.77)10this scale were taken out of which patient scored 30.

TREATMENT

For the physiotherapeutic intervention, the patient was given 6-week follow up exercises (Shown in table 2) were given as follows:

Balance training

This balance training consists of six stages. If the patient is able to finish stage 1 or consecutive stages, they can proceed directly to the next stages with Stage 1: Standing upright with eyes open Stage 2: Standing upright with eyes closed Stage 3: Standing in tandem stance (eyes open) Stage 4: Standing in tandem stance with eyes closed Stage 5: One leg standing (eyes open)Stage 6: One leg standing (eyes closed) all the posture is maintained for 30 seconds and repeated for 3 times.

Gait training

The gait training process is divided into three stages. If the patient can finish stage 1 or successive levels, they can proceed directly to the next stages. Stage 1: In this training, the patient walks backward. Stage 2: During this training, the patient to walk forward with horizontal and vertical head turns. Stage 3: In this training, the patient walks forward and crosses all obstacles and the patient ascent and descends one floor of stairs.

Incoordination management

Frankel's exercise[11-13] and Coordination Drills like task specific training were given to the patient.

Dizziness management

Brandt-Daroff Exercise[7]: Patient Sit upright on the edge of a bed, then turn their head to 45 degrees to the left and lies down on the right side; hold for 30 seconds or until dizziness resolves. then sits up, face forward, then turns head 45 degrees to the right and lies on left side for 30 seconds. then Sit up again; this completes one cycle. Repeating for 5 times 5 sessions a week were given.

Table 2: Summary of the structured physiotherapy intervention program administered over a six-week period

Component	Exercises (examples)	Frequency	Duration per session	Repetitions/Sets	Progression criteria
Trunk strengthening	Supine abdominal curl-ups, prone trunk extension	5×/week	30 min	10 reps × 3 sets	Increase reps/hold time when RPE < 13
Coordination	Frankel's exercises, finger-nose, Archimedes spiral practice	5×/week	20 min	10×/exercise	Increase speed or add dual-task
Balance	7-stage protocol Stage 1: Standing upright with eyes open Stage 2: Standing	daily	15 min	3 × 30s holds	Move to next stage if 3/3 holds maintained

	upright with eyes closed Stage 3: Tandem stance with eyes open Stage 4: Tandem stance with eyes closed Stage 5: Single leg stance with eyes open Stage 6: Single leg stance with eyes closed				
Gait	Stage 1 Backward walking Stage 2 Forward walking Stage 3 Obstacle walking	3–5×/week	20 min	10 min walking practice	Increase distance/speed
Vestibular	Brandt-Daroff	5 sessions/week	5 min	5 cycles	Reduce Dizziness

FOLLOW UP:

Table 3: The pre-and post-intervention score of outcome measure

Sr No	Outcome measure	Pre intervention 0 week (scores/seconds)	Follow up at 2nd week	Follow up at 4th week	Follow up at 6th week
1	ICARS	40	37	32	30
2	BBS	30	32	35	38

DISCUSSION

Patient with Pancerebellar Ataxia with pyramidal tract involvement tends to have difficulty in ambulation and balance to test the balance, BBS were used as the outcome measure. as interpretation of this scale ranges from total score of 56 with 41-56 score; “low risk of fall”,21-40“moderate risk of fall”,0-20 “high risk of fall” and a significant increase in score >8 10 .in the patient the score at the first day of treatment was 30 and have a significantly improved after 6 week of balance training, the BBS score of 38. The improvement in balance is attributed to enhance sensory integration, neuromuscular re-education, and motor learning accomplished by tailored physiotherapeutic activities[11]. Balance training encourages the integration of visual, vestibular, and proprioceptive information, improves postural corrections, and develops core and lower limb muscles, all of which contribute to increased stability and coordination[11].

Study by Ahn. J et al.[14]says that Balance training based on the Berg balance scale can enhance balance skills in patients with cerebellar ataxia, and the Berg balance scale group demonstrated improved clinical outcomes. While on assessing coordination ICARS scale were taken as outcome measure. as interpretation of this scale ranges from total score of 100 with 0-30: “mild ataxia”,31-60: “moderate ataxia”,61-100: “severe ataxia”9. In the patient there was improvement in score of ICARS were found.as a study by Chien. H et al.[13]suggested that Intensive coordinative training programs have shown benefits in reducing ataxia severity and improving activities of daily living. while a study by Miao He et al.[11] conducted a systematic review that Conventional physiotherapy treatment like coordination exercises, balance, gait training can improve balance and coordination for people with genetic degenerative ataxia.

These findings support the effectiveness of a structured physiotherapy program in restoring balance and coordination through neuroplasticity-driven adaptation and motor relearning, even in individuals with complex neurological involvement.

Limitations and Future Recommendations

In this study, some advanced imaging or testing were unable to be completed due to resource limitations. The genetic mutation information was due to resource limitations. This report is a single case study; the results cannot be extended to a larger population. The small follow-up period limits our understanding of the long-term outcomes.

CONCLUSION

In this study, some advanced imaging or testing were unable to be completed due to resource limitations. The genetic mutation information was due to resource limitations. This report is a single case study; the results cannot be extended to a larger population. The small follow-up period limits our understanding of the long-term outcomes.

Abbreviation

ICARS – "The International Cooperative Ataxia Rating Scale"
BBS – "Berg Balance scale"

Declaration by Authors

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