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Enhancing the Functional Recovery of Upper Extremities in Guillain Barre Syndrome for 10-year-Old by Combining Immersive Virtual Reality with Conventional Rehabilitation - A Unique Case Study

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ABSTRACT

Background: Guillain-Barré Syndrome (GBS) is a rare autoimmune disorder affecting the peripheral nervous system, characterized by muscle weakness and pain. While conventional physiotherapy (PT) is a standard treatment, emerging technologies like immersive virtual reality (IVR) may enhance the rehabilitation outcome.

Objective: This case study aimed to investigate the efficacy of combining IVR with conventional PT in the rehabilitation of a 10-year-old male diagnosed with GBS, focusing primarily on upper extremity (UE) function.

Methods: The patient presented with bilateral weakness in the upper and lower extremities, along with difficulty in transitioning between positions, and reported pain in B/L UE. Conventional PT, supplemented with IVR specifically targeting UE function, was administered. Outcome measures included pain assessment using the Numerical Pain Rating Scale (NPRS), muscle power evaluation via the Medical Research Council scale (MRC), and functional independence assessed with the Functional Independence Measure (FIM).

Results: Following the intervention, the patient exhibited significant improvements in pain reduction from 8/10 to 1/10, muscle power in the shoulder and elbow from 2/5 to 4/5, and wrist and finger muscles from 3/5 to 4/5. Additionally, enhancements in self-care and transfer components of FIM demonstrated increased independence in activities of daily living.

Conclusion: Combining IVR with conventional PT provides a unique rehabilitation approach that enhances recovery. This approach fosters active participation, immersion, and motivation within a stimulating and enjoyable environment, which is particularly appealing for a 10-year-old patient. This case study represents the pioneering use of virtual reality in pediatric Guillain-Barré Syndrome rehabilitation, particularly in the Indian context.

Keywords: Guillain Baree Syndrome, Immersive Virtual Reality, Pediatric rehabilitation, Gamified exercise program.

INTRODUCTION

Guillain-Barré syndrome (GBS) is an autoimmune disorder characterized by acute peripheral neuropathy (1). Although there is no precise incidence, an Indian study reports that the incidence of GBS is 48.8 to 85.2% in adults (2). According to the World Health Organisation (WHO), the annual incidence in childhood ranges from 0.6 to 4 cases per 100000. Young children are more susceptible to infections, and studies on GBS in children have yielded conflicting results regarding the age groups most affected. While some studies report a higher incidence in those under 5 years old, others suggest a peak in children aged 5 to 10 years. However, there is general agreement that GBS occurs less frequently in children older than 10 years (3).

The primary clinical characteristics of Guillain-Barré Syndrome (GBS) encompass sensory and motor impairments, including gradually worsening limb weakness and absence of reflexes. These impairments manifest in various muscle groups, affecting the lower limbs, trunk, and upper extremities. Additionally, patients experience bilateral facial paralysis, involvement of bulbar muscles, cranial nerve dysfunction, and respiratory issues (4). There are different clinical categories which include acute inflammatory demyelinating polyradiculoneuropathy (AIDP), Miller Fisher syndrome (MFS), acute motor axonal neuropathy (AMAN), and acute motor sensory axonal neuropathy (AMSAN) (4).

Rehabilitation plays a crucial role in the recovery process for children with GBS aiming to maximize functional independence and quality of life. Several factors influence the rehabilitation of childhood GBS, age, preceding illness, rate of progression, extent of disability, family support, and time of therapeutic intervention (1). Conventional rehabilitation techniques are tedious, monotonous, and boring with low adherence to treatment. New technologies like Immersive virtual reality (IVR) assisted conventional rehabilitation have potential solutions to these limitations.

This case study presents a rare 10-year-old child from India with GBS. The child underwent a conventional rehabilitation integrated with IVR to the upper extremity (UE) and the study discusses the outcome of this treatment approach.

CASE REPORT

Patient History:

The patient is a 10-year-old male, who presented with complaints of fever, cold, weakness and pain in upper and lower extremities (UE &LE), difficulty in micturition, and bowel movement for 5 days. Initially, he experienced difficulty in sitting to standing and eventually lost the ability to walk. So, he was taken to the hospital on 10/03/24, and following physical examination and investigation he was diagnosed with GBS - Acute inflammatory demyelinating polyneuropathy variant (AIDP). There was no respiratory complication.

Investigation:

Nerve conduction velocity (NCV):
11/03/2024

Shows symmetrical length-dependent demyelination leading to secondary axonal degeneration type of radiculopathy predominantly affecting the motor fibres.

Course in-hospital stay:

Immediately following diagnosis, he was admitted to the Paediatric Intensive Care Unit (PICU) and commenced treatment with intravenous immunoglobulin (IVIG) and Physiotherapy. Additionally, he was catheterized and was in the nasogastric (NG) tube. By 4th day of the admission, both the catheter and NG tube were weaned off as the patient regained a voiding sensation and began tolerating oral feed. He demonstrated improvement by being able to lift his head. There was no deterioration in the limb weakness. So, he was shifted to the ward. Ensuring his hemodynamic stability

and no worsening of symptoms he was discharged on 18/03/24.

Commencement of rehabilitation:
Post-discharge patient presented to Ciranjev Rehab Centre, Chidambaram on 23/03/24 to address the lingering impacts of his condition. His primary concern was weaknesses in B/L UE and LE, B/L shoulder pain, and difficulty in the transition of position from sitting to standing, standing, and walking leading to restriction in functional activities of daily living. He also had sensory disturbances in the foot.

On Examination:
The patient was alert, comprehending, and oriented. The respiratory system was normal. Given the focus of this case study on upper extremity observations, the assessments regarding the upper extremities are reported. The pain in the B/L shoulder is 8/10 according to the Numerical pain rating scale (NRRS) (refer to Table 1). According to the Medical Research Council (MRC) Scale the muscle power was 2/5 in B/L shoulder and elbow musculature and 3/5 in B/L wrist and finger musculatures (refer to Table 2.1 and 2.2). The Functional Independence Measure (FIM) was utilized to evaluate functional activities of daily living, specifically focusing on motor components such as self-care and transfers. Within the self-care category of FIM, tasks such as eating, grooming, bathing, UE dressing, and in the transfer category of FIM, tasks like moving from bed to chair and toileting required total assistance, denoted by a score of 1(refer to Table 3).

Drug Prescription:
The patient was prescribed a daily regimen of Oxetol 150, Nurowire, and Juviana Plus for a period of 30 days.

Rehabilitation Intervention with Immersive Virtual Reality (IVR):
The patient underwent conventional physiotherapy to UE along with IVR therapy. The conventional Physiotherapy (PT) regimen included mobility exercises, resisted exercises, and strengthening exercises to UE. The IVR was given for 15-20 min daily for 27 sessions throughout treatment (refer to Figure 1). The therapeutic UE IVR games include penguin, fruit catch, boxing, butterfly bloom burst, flying fish, and hen harvest. These therapeutic games serve the purpose of pain reduction, facilitation of muscle power, increase muscle endurance, assist in repetitive functional movements provide real-time feedback, and even encourage and motivate the patient towards the therapy program. The therapeutic parameters of each game were customized based on the patient's status. Additionally, relaxation therapy was incorporated using the focus temple and the forest game

Outcome
The primary outcome includes pain, muscle power, and the functional status of the UE, which was assessed with NPRS, MRC Scale, and FIM. Within 7-8 sessions of combined VR and conventional PT the pain reduced from 8/10 to 1/10 (refer to Table 1). Over the course of 27 sessions of VR combined with conventional PT the muscle power improved from 2/5 in the shoulder and elbow to 4/5, while in the wrist and fingers, it improved from 3/5 to 4/5 (refer to Table 2.1 and 2.2). The functional activities of daily living which were evaluated with FIM have also shown improvement in self-care and transfer components (refer to Table 3). Although the main focus was on evaluating upper extremity function, the patient's general functional improvement was also assessed using the GBS disability scale, which showed progress from a score of 4 to 2 (refer to Table 4)

Figure 1

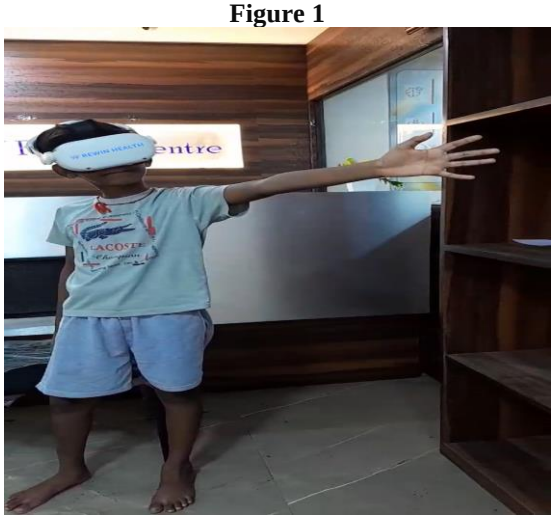

Table 1: Pre and Post analysis of pain

Pain	Pre 23/03/24	Post 23/04/24
NPRS	8/10	1/10

Table 2.1: Pre and Post analysis of muscle power - Right UE

MRC Scale Right UE	Pre 23/03/24	Post 23/04/24
Shoulder Flexor	2/5	4/5
Shoulder Extensor	2/5	4/5
Shoulder Adductor	2/5	4/5
Shoulder Abductor	2/5	4/5
Shoulder Internal Rotators	2/5	4/5
Shoulder External Rotators	2/5	4/5
Elbow flexor	2/5	4/5
Elbow extensor	2/5	4/5
Wrist flexor	3/5	4/5
Wrist extensor	3/5	4/5
Finger flexor	3/5	4/5
Finger extensors	3/5	4/5

0- No contraction, 1- Flicker or trace of contraction, 2- Active movements with gravity eliminated,
3- Active movements against gravity, 4- Active movement against resistance, 5- Normal Strength

Table 2.2: Pre and Post analysis of muscle power - Left UE

MRC Scale Left UE	Pre 23/03/24	Post 23/04/24
Shoulder Flexor	2/5	4/5
Shoulder Extensor	2/5	4/5
Shoulder Adductor	2/5	4/5
Shoulder Abductor	2/5	4/5
Shoulder Internal Rotators	2/5	4/5
Shoulder External Rotators	2/5	4/5
Elbow flexor	2/5	4/5
Elbow extensor	2/5	4/5
Wrist flexor	3/5	4/5
Wrist extensor	3/5	4/5
Finger flexor	3/5	4/5
Finger extensors	3/5	4/5

0- No contraction, 1- Flicker or trace of contraction, 2- Active movements with gravity eliminated,
3- Active movements against gravity, 4- Active movement against resistance, 5- Normal Strength

Table 3: Pre and Post analysis of UE functional activities

FIM	Pre 23/03/24	Post 23/04/24
Self-care		
Eating	1	5
Grooming	1	4
Bathing	1	5
Dressing UE	1	4
Transfers		
Transfer to bed, chair	1	6
Toilet	1	6

1- Total assistance, 2- Maximal assistance, 3- Moderate assistance, 4- Minimal assistance, 5- Supervision, 6-Modified independence, 7- Complete independence

Table 4: Pre and Post analysis of GBS Disability Scale

GBS Functional status	Pre 23/03/24	Post 23/04/24
GBS Disability Scale	4	2

0- A healthy state, 1- Minor symptoms and capable of running
2- Able to walk 10m or more without assistance but unable to run,
4- Bedridden or chair-bound, 5- Requiring assisted ventilation for at least part of the day,
6-Modified independence, 7- Dead

DISCUSSION

This case study examines the use of interactive IVR in conjunction with conventional physical therapy for the rehabilitation of UE function in patients with GBS. This choice of approach was adopted as UE dysfunction is one of the neuromotor impairments in GBS which may restrict the functional activities of daily living influencing social participation and decline in quality of life. In this scenario, IVR along with conventional PT was given to reduce B/L shoulder pain and improve the UE neuromuscular coordination (5).

Analytical framework:

The analytical framework for this approach may rely on experiential learning, augmented feedback, and motivation. Experiential learning encompasses physical, mental, and emotional interaction and encourages active participation and involvement of the user (6). In this case, the rehabilitation of the UE e.g., Various gamification techniques in VR were utilized to promote shoulder flexion and abduction, offering functional movement.

Moving on with the next theoretical background the augmented feedback through visual, auditory, and kinaesthetic sensations. Along with multimodal sensory stimulation VR also provides feedback on the knowledge of the performance throughout the game play in the form of movement kinematics like joint angles, speed, velocity, muscular force sense, and knowledge of the results following the completion of the task (6).

Importantly, VR therapy breaks the monotonicity of the exercises and actively involves and motivates the patient for rehabilitation. This is a fact in this case, as the patient is just 10 years old, and making him perform the traditional exercises might not involve him in the VR-assisted therapy program.

CONCLUSION

VR-assisted conventional therapy offers repetitive intensive tasks with immediate sensory-motor feedback on performance with active engagement, immersion, and motivation within an enjoyable and playful environment. The outcome of this case is evident that IVR-assisted UE rehabilitation offers a promising approach to enhancing motor recovery in pediatric GBS. It is a more attractive option in this case as he was a child. To our knowledge, this was the first case report that explored VR in pediatric GBS, especially within the Indian population.

WAY FORWARD

- Further research should explore the long-term benefits and the efficacy of more samples especially in the Indian sector.
- The VR-assisted conventional PT has been explored in LE and balance training too.
- This study has limited his findings to a period of 2 months from the time of GBS onset.

Declaration by Authors

Ethical Approval: Not Applicable since it is a case study. Informed consent is obtained from the concerned patient.

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Conflict of Interest: The authors declare no conflict of interest.

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