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Functional Recovery After Neurorehabilitation and Ventriculoperitoneal Shunting in Pediatric Tuberculous Meningitis-Associated Hydrocephalus: A Case Report

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Abstract
Introduction: *Tuberculous meningitis in children may cause hydrocephalus and neurological disability despite treatment, while evidence on rehabilitation after ventriculoperitoneal shunting remains limited.* ***Objective:*** *To describe functional recovery following multidisciplinary neurorehabilitation in a child with tuberculous meningitis-associated hydrocephalus after ventriculoperitoneal shunting.* ***Case Report:*** *A case report was conducted in a 9-year-old boy with grade II tuberculous meningitis, communicating hydrocephalus, bilateral lower-limb weakness, and urinary retention. The rehabilitation program included progressive resistance exercise, transfer and mobility training, gait training, dressing training, and bladder management.* ***Results and Discussion:*** *Initially, lower-limb muscle strength was approximately 3/5, and the patient required wheelchair mobility and intermittent catheterization. Following rehabilitation, strength improved to 4/5, with progression to standing, walker-assisted ambulation, independent transfers, and spontaneous urination, allowing discontinuation of catheterization.* ***Conclusions:*** *Multidisciplinary, goal-directed neurorehabilitation combined with bladder management may support recovery of mobility, self-care, and urinary function in children with tuberculous meningitis-associated hydrocephalus after ventriculoperitoneal shunting.*

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Introduction

Tuberculous meningitis (TBM) is one of the most severe forms of tuberculosis in children and remains an important cause of mortality and long-term neurological disability despite appropriate antituberculosis treatment (Nataprawira *et al*., 2022; van Toorn & Solomons, 2023). A retrospective cohort from Hasan Sadikin Hospital, Bandung, Indonesia, reported severe neurological sequelae among survivors of childhood TBM, with baseline motor deficits and advanced disease stage associated with poorer neurological outcomes (Nataprawira *et al*., 2022). These findings show the substantial neurological burden of pediatric TBM in Indonesia. Hydrocephalus is a major neurological complication of TBM caused by inflammatory exudates at the basal meninges that interfere with cerebrospinal fluid circulation and absorption, resulting in ventricular enlargement and increased intracranial pressure (van Toorn & Solomons, 2023; Yiek & Wong, 2022). It is associated with increased mortality and unfavorable neurological outcomes, while its management remains complex and lacks universally accepted neurosurgical protocols (Nataprawira *et al*., 2022; Yiek & Wong, 2022). Cerebrospinal fluid diversion, including ventriculoperitoneal (VP) shunting, is commonly used in patients with clinically significant hydrocephalus (Yiek & Wong, 2022).

VP shunting can alleviate hydrocephalus-related intracranial hypertension, but resolution of hydrocephalus does not necessarily result in complete neurological or functional recovery (Yiek & Wong, 2022; Zhang *et al*., 2023). Persistent deficits may result from inflammatory brain injury, cerebral vasculopathy, ischemia or infarction, raised intracranial pressure, and physical deconditioning (Nataprawira *et al*., 2022; Yiek & Wong, 2022). In pediatric TBM survivors, these consequences may include motor impairment, developmental difficulties, seizures, sensory deficits, and limitations in activities and participation (Nataprawira *et al*., 2022; van Toorn & Solomons, 2023). Rehabilitation is therefore important during the subacute phase to address residual impairments and improve mobility, activities of daily living (ADLs), and participation. Evidence from pediatric acquired brain injury (ABI) populations suggests that subacute rehabilitation can improve functional recovery, although the evidence remains heterogeneous and largely based on cohort studies and case reports (Gmelig Meyling *et al*., 2022). A 10-year retrospective study of 266 children with subacute ABI reported improvements in gross motor function, balance, and walking endurance during inpatient rehabilitation, with ambulation among the major physiotherapy goals (Ryan *et al*., 2023).

Pediatric ABI rehabilitation recommendations emphasize individualized, participation-focused interventions based on the child's age, developmental stage, clinical presentation, functional goals, and rehabilitation needs (Gmelig Meyling *et al*., 2022; Gmelig Meyling *et al*., 2023). Expert consensus also supports family involvement in goal setting and therapeutic activities, although the optimal rehabilitation dose and dose-response relationship remain insufficiently established (Gmelig Meyling *et al*., 2023). The International Paediatric Brain Injury Society similarly emphasizes comprehensive post-acute rehabilitation to address multidimensional consequences and support reintegration into home, school, and community environments (Linden *et al*., 2024). However, evidence specifically addressing rehabilitation for TBM-associated neurological disability remains limited. Most available evidence is derived from heterogeneous pediatric ABI populations rather than TBM specifically (Gmelig Meyling *et al*., 2022; Ryan *et al*., 2023; Gmelig Meyling *et al*., 2023; Linden *et al*., 2024). Clinical reports describing individualized rehabilitation in children recovering from TBM may

therefore provide useful information for rehabilitation physicians and multidisciplinary teams.

The present case describes a school-aged child with TBM-associated communicating hydrocephalus who developed severe bilateral lower-extremity weakness, loss of ambulation, ADL limitations, and impaired spontaneous urination following the acute neurological illness and VP shunt placement. The rehabilitation program was individualized according to the patient's impairments, functional limitations, and rehabilitation goals. It incorporated resistance exercise, task-specific transfer and gait training, ADL training, bladder management, and family involvement. The program aimed to improve lower-extremity strength, mobility, independence in daily activities, and urinary function during the subacute rehabilitation period. This case shows the functional progression of a child following TBM-associated hydrocephalus and VP shunting. It also provides clinical information on the application of multidisciplinary, goal-directed neurorehabilitation in addressing persistent motor, mobility, self-care, and bladder-related limitations after pediatric TBM.

Case Report

Patient Characteristics

A 9-year-old boy was referred to the Department of Physical Medicine and Rehabilitation for a pediatric neurorehabilitation program three weeks after undergoing ventriculoperitoneal (VP) shunt placement for communicating hydrocephalus associated with grade II tuberculous meningitis (TBM). Before the illness, he was a third-grade elementary school student who was independently mobile and performed activities of daily living (ADLs) independently, with hobbies including playing hide-and-seek and futsal. Approximately one month before rehabilitation assessment, he developed bilateral lower-limb weakness resulting in loss of ambulation and impaired spontaneous urination. Following hospitalization, he was diagnosed with communicating hydrocephalus associated with TBM and underwent VP shunt placement. At rehabilitation assessment, he remained wheelchair-dependent with caregiver assistance and required partial assistance for lower-body dressing, toileting, and bathing, while urinary management was performed using CIC every four hours. His family provided strong support throughout the rehabilitation process, with his mother serving as the primary caregiver and assisting with CIC and home-based rehabilitation.

Baseline Clinical Examination

Physical examination showed a child with normal nutritional status and a body mass index of 19.39 kg/m². Neuromusculoskeletal examination revealed preserved upper-extremity strength with manual muscle testing (MMT) of 5/5, whereas both lower extremities were weak with an average MMT of 3/5. The patient was able to perform hip flexion, knee flexion, ankle dorsiflexion, plantarflexion, and great-toe extension, although these movements were weak. Lower-extremity range of motion was preserved without documented deformity or clinically evident spasticity. Sensory function was preserved, including light touch, pin-prick, proprioception, and visual and auditory functions. Cognitive examination showed preserved consciousness, attention, memory, and ability to follow commands. Head CT showed communicating hydrocephalus accompanied by a cavum vergae cyst, without evidence of intracranial hemorrhage on the reported examination. The patient also had impaired spontaneous urination and required clean intermittent catheterization every four hours.

This case report describes the implementation of an individualized pediatric neurorehabilitation program in a 9-year-old boy with communicating hydrocephalus associated with tuberculous meningitis following ventriculoperitoneal (VP) shunt placement. The rehabilitation plan was formulated based on a comprehensive assessment of the patient's medical and rehabilitation diagnoses, functional limitations, bladder function, activity limitations, environmental support, prognosis, and patient-centered rehabilitation goals. The main rehabilitation problems were mobility and activities of daily living (ADL) limitations secondary to bilateral lower-extremity muscle weakness, accompanied by neurogenic lower urinary tract dysfunction (NLUTD). The rehabilitation goals focused on improving lower-extremity strength to facilitate sit-to-stand and standing, progressing transfer ability, achieving greater independence in ADLs, and maintaining renal function while preventing bladder complications. Long-term functional goals included independent walking and independent ADL performance.

The rehabilitation program was individualized according to the patient's baseline motor function and functional limitations. Lower-extremity resistance training was prescribed using isotonic resistance-band exercises twice daily, with 8-10 repetitions performed until slight fatigue, aiming to improve antigravity lower-extremity strength required for standing and subsequent mobility. Upper-extremity resistance training was also performed twice daily using resistance bands or dumbbells for 8-10 repetitions until slight fatigue to improve upper-extremity strength required for transfers and wheelchair mobility.

Functional training was incorporated alongside strengthening to facilitate translation of motor recovery into meaningful activities. Transfer training was initially directed toward same-level transfers and subsequently progressed toward different-level transfers as functional capacity improved. Gait training was subsequently performed using parallel bars and a walker as the patient's lower-extremity strength and standing ability improved. ADL training focused on lower-body dressing and transfer from the wheelchair to the toilet to reduce caregiver dependence.

Bladder management was incorporated into the rehabilitation program because the patient was unable to urinate completely and required clean intermittent catheterization (CIC) every four hours at baseline. The program included scheduled CIC, a voiding diary, and regulation of fluid intake, with the objective of maintaining renal function and preventing bladder complications while spontaneous voiding recovered. The patient's family was actively involved in the rehabilitation process, with the mother serving as the primary caregiver and performing CIC.

The rehabilitation program was progressively modified according to functional recovery. At the first follow-up, the patient had progressed to sitting and standing and was beginning independent lower-body dressing training, while resistance training, bladder management, and same-level transfer training were continued. At the subsequent follow-up, when the patient was able to walk using a walker and urinate spontaneously without CIC, the program was progressed to different-level transfer training and gait training using parallel bars and a walker, with a recommendation for return to school.

Table 1
Individualized Rehabilitation Program

Baseline condition	Intervention
Lower-extremity MMT approximately 3/5; able to resist gravity but unable to maintain functional standing	Isotonic resistance exercise using resistance bands; 2×/day, 8-10 repetitions, until slight fatigue
Upper extremities sufficient for changing position but not yet adequate for independent transfer and wheelchair mobility	Isotonic resistance exercise using resistance bands/dumbbells; 2×/day, 8-10 repetitions, until slight fatigue
Unable to perform functional transfers independently	Same-level transfer training, subsequently progressed to different-level transfer training
Unable to walk and dependent on wheelchair mobility	Standing and gait training using parallel bars and walker
Required parental assistance for lower-body dressing	Unassisted lower-body dressing exercises
Required assistance and CIC for urinary management	Wheelchair-to-toilet transfer training
Unable to urinate completely; CIC every 4 hours	Scheduled CIC every 4 hours, voiding diary, and fluid-intake regulation

Results and Discussion

1. Results

The patient showed progressive functional recovery following the individualized pediatric neurorehabilitation program. At baseline, he presented with bilateral lower-extremity weakness with an average manual muscle testing (MMT) score of 3/5, was unable to ambulate, and required caregiver-assisted wheelchair mobility and partial assistance with activities of daily living (ADLs). Urinary dysfunction was also present, with impaired spontaneous urination requiring clean intermittent catheterization (CIC) every four hours.

By week 5, the patient showed early motor and functional improvement, with the ability to sit and stand and to maintain standing while holding onto support. Lower-extremity muscle strength remained predominantly at MMT 3/5, although ankle dorsiflexion and plantarflexion had improved to 4/5, while upper-extremity strength remained normal at 5/5. Spontaneous urination had begun to recover, although CIC every four hours was still continued as part of bladder management.

Further improvement was observed by week 8. The patient was able to ambulate using a walker, transfer from the wheelchair at the same level, and urinate spontaneously without further CIC. Lower-extremity strength improved to MMT 4/5 across the hip, knee, ankle, and long-toe extensor muscle groups, while upper-extremity strength remained 5/5. Based on these improvements, the rehabilitation program was progressed from same-level transfer training to different-level transfer training and gait training using parallel bars and a walker, and a recommendation for return to school was provided.

Table 2
Clinical Progression During Pediatric Neurorehabilitation

Outcome	Baseline	Week 5	Week 8	Change (Baseline-Week 8)
Lower-extremity MMT	3/5	Predominantly 3/5; ankle DF/PF 4/5	4/5	+1 grade
Upper-extremity MMT	5/5	5/5	5/5	Maintained
Sitting ability	Unable to perform functional mobility independently	Able to sit	Independent sitting	Improved
Standing ability	Unable to stand	Able to stand with support	Able to stand and progress to walking with walker	Improved
Ambulation	Unable to walk; caregiver-assisted wheelchair mobility	Not yet independently ambulatory	Walking using walker	Improved
Transfer	Dependent/assisted	Same-level transfer training	Able to transfer wheelchair-to-same-level surface; progressed to different-level transfer training	Improved
Lower-body dressing	Required assistance	Independent training initiated	Continued functional training	Improved
Urinary function	Unable to urinate spontaneously; CIC every 4 h	Spontaneous urination beginning; CIC continued	Spontaneous urination; CIC discontinued	Improved
Bladder management	CIC every 4 h	CIC every 4 h with fluid regulation	No longer required CIC	Resolved
Gait training	Not ambulatory	Standing preparation	Parallel bar/walker training	Progressed
School participation	Unable to attend school because of mobility limitation	Rehabilitation ongoing	Recommendation for return to school	Improved

Baseline findings were obtained at the initial rehabilitation assessment, while week 5 and week 8 represent the first and second follow-up assessments, respectively. The week 5 assessment documented preserved upper-extremity strength, predominantly 3/5 lower-extremity strength, emerging standing ability, and initiation of spontaneous urination. The week 8 assessment documented 4/5 strength across the assessed lower-extremity muscle groups, walker-assisted ambulation, spontaneous urination without CIC, and progression of transfer and gait training.

The observed progression showed improvement across the major rehabilitation domains, particularly lower-extremity muscle strength, postural control, mobility, transfers, and bladder function. At baseline, the patient was unable to walk and depended on caregiver-assisted wheelchair mobility, whereas by week 8 he had progressed to walker-assisted ambulation and functional transfer training. The improvement in lower-

extremity strength from approximately MMT 3/5 to 4/5 was accompanied by a clinically meaningful change in functional mobility, suggesting that the strengthening program was successfully translated into task-specific activities such as standing, transfers, and gait.

Then, an important functional recovery was also observed in bladder function. At baseline, the patient required CIC every four hours because of impaired spontaneous urination, whereas by week 8 he was able to urinate spontaneously and no longer required CIC. This improvement occurred in parallel with motor recovery and was accompanied by continued bladder-management strategies during the earlier phase of rehabilitation.

The clinical progression supported the feasibility of an individualized, function-oriented rehabilitation approach in a child with bilateral lower-extremity weakness and neurogenic lower urinary tract dysfunction following tuberculous meningitis-associated hydrocephalus and VP shunt placement. The progression from assisted wheelchair mobility to supported standing and subsequently walker-assisted ambulation, together with recovery of spontaneous urination, represents improvement across both body functions and activities, consistent with the rehabilitation objectives established at baseline

2. Discussion

Tuberculous meningitis (TBM) is one of the most severe forms of childhood tuberculosis and may result in substantial mortality and long-term neurological disability, including motor, cognitive, developmental, and functional impairments (Huynh *et al*., 2022; du Preez *et al*., 2022). Hydrocephalus is an important complication that may contribute to persistent disability even after acute infection and neurosurgical management have been addressed (van Toorn & Solomons, 2023). Rehabilitation is therefore relevant during the post-acute phase to address neurological impairments as well as limitations in mobility, activities of daily living (ADLs), bladder function, and participation (Huynh *et al*., 2022; Saal *et al*., 2023). In the present case, the patient initially had bilateral lower-extremity weakness, inability to ambulate, caregiver-assisted wheelchair dependence, and partial dependence in ADLs after TBM-associated communicating hydrocephalus and VP shunt placement. These findings are consistent with the recognized spectrum of post-TBM disability, which may persist despite treatment of the underlying infection (Huynh *et al*., 2022). A retrospective cohort study further reported that 21.7% of children with TBM had moderate-to-severe developmental impairment, while impaired motor function at presentation was associated with poorer developmental outcomes (Saal *et al*., 2023).

The motor impairment observed in this case is clinically relevant because neurological sequelae are common among children surviving TBM. A retrospective cohort from Hasan Sadikin Hospital reported severe neurological sequelae in 36.3% of survivors with documented outcomes, with motor disorders accounting for 66.7% of these sequelae (Nataprawira *et al*., 2022). Baseline motor deficit was also independently associated with severe neurological sequelae at treatment completion, with an adjusted OR of 3.64 (95% CI 1.19-11.16) (Nataprawira *et al*., 2022). The mechanisms underlying such impairment may include meningeal inflammation, hydrocephalus, cerebral vasculopathy, ischemia or infarction, and subsequent physical deconditioning (Nataprawira *et al*., 2022; van Toorn & Solomons, 2023; Yiek & Wong, 2022). Rehabilitation in this phase therefore targets the functional consequences of neurological injury rather than the underlying Mycobacterium tuberculosis infection. The present case

shows this approach by addressing the patient's lower-extremity weakness through progressive strengthening and functional mobility training.

The rehabilitation program combined resistance exercise with task-specific training to support progression toward functional mobility. Lower-extremity strengthening was directed toward developing the force required for antigravity activities, standing, transfers, and gait, while functional training translated these gains into meaningful activities. This approach is consistent with evidence suggesting that rehabilitation may reduce neurological sequelae following tuberculosis, although the available evidence remains limited and heterogeneous (Alene *et al*., 2024; Igbokwe *et al*., 2023). A systematic review and meta-analysis found that rehabilitation interventions were associated with a lower risk of post-tuberculosis neurological sequelae, supporting rehabilitation as part of the continuum of care rather than merely an adjunct to acute treatment (Alene *et al*., 2024). Reports specifically involving TBM have also described improvements following structured rehabilitation, including a six-week intensive physiotherapy program involving progressive mobility, postural strengthening, transfer, and ADL training (Pakhan & Raghumahanti, 2024). Similarly, a case series of severe TBM reported improvement in neurological status and functional disability following comprehensive rehabilitation initiated during intensive care and continued after transfer to a high-care setting (Suisan & Thohari, 2022). Although these uncontrolled reports cannot establish treatment efficacy, they support the feasibility of structured, impairment-directed, and function-oriented rehabilitation in TBM-related neurological disability.

Then, an important feature of the present program was the progression from impairment-focused exercise to task-specific functional activities. Once the patient developed sufficient postural control and lower-extremity capacity, training progressed through standing, transfers, and gait using parallel bars and a walker. This progression reflects the principle that rehabilitation should be individualized according to the child's functional capacity and directed toward meaningful activity and participation (Gmelig Meyling *et al*., 2022; Linden *et al*., 2024). Pediatric ABI recommendations similarly emphasize interventions based on age, developmental stage, clinical presentation, functional goals, and rehabilitation needs (Gmelig Meyling *et al*., 2022; Gmelig Meyling *et al*., 2023). In a 10-year retrospective study of 266 children with subacute ABI, improvements in gross motor function, balance, and walking endurance were observed during inpatient rehabilitation, with ambulation among the major physiotherapy goals (Ryan *et al*., 2023). However, the optimal rehabilitation dose, intensity, and dose-response relationship remain insufficiently established, particularly for children with post-TBM disability (Gmelig Meyling *et al*., 2023; Alene *et al*., 2024). Thus, the progression used in this case should be regarded as an individualized clinical strategy rather than a standardized TBM-specific rehabilitation protocol.

Recovery of urinary function was another clinically important outcome in this case. At baseline, the patient had impaired spontaneous urination and required clean intermittent catheterization (CIC) every four hours, while spontaneous voiding began to recover during the early rehabilitation phase. By the second follow-up, he was able to urinate spontaneously and CIC was discontinued. CIC is an established strategy for pediatric neurogenic lower urinary tract dysfunction because regular bladder emptying can reduce urinary retention and help protect the upper urinary tract when bladder emptying is inadequate (Sager *et al*., 2022). The 2023 Canadian Urological Association and Pediatric Urologists of Canada guideline recommends individualized CIC management according to bladder and upper urinary tract risk, clinical status, and patient

and family readiness (Chua *et al*., 2023). In this case, rehabilitation provided scheduled CIC, a voiding diary, fluid-intake regulation, caregiver education, and monitoring while neurological recovery occurred. Nevertheless, spontaneous urinary recovery cannot be attributed specifically to rehabilitation because TBM recovery, hydrocephalus treatment, VP shunting, and neurological recovery occurred concurrently (van Toorn & Solomons, 2023; Saal *et al*., 2023).

Family involvement also supported the implementation of rehabilitation beyond supervised clinical sessions. The patient's mother served as the primary caregiver and participated in CIC and home-based rehabilitation, allowing therapeutic activities to be incorporated into daily routines. This approach is consistent with pediatric ABI recommendations supporting family involvement in goal setting and therapeutic activities (Gmelig Meyling *et al*., 2023). Comprehensive post-acute rehabilitation also emphasizes addressing multidimensional consequences of acquired brain injury and supporting reintegration into home, school, and community environments (Linden *et al*., 2024). In the present case, preserved cognition, sensory function, upper-extremity strength, and joint range of motion provided a favorable basis for active rehabilitation, while bilateral lower-extremity weakness represented the principal functional limitation. The relatively preserved neurological domains allowed rehabilitation to focus primarily on strengthening, transfers, gait, ADLs, and bladder management. These observations reinforce the importance of early functional assessment and individualized rehabilitation after acute neurological and neurosurgical management of pediatric TBM (Huynh *et al*., 2022; Nataprawira *et al*., 2022; Alene *et al*., 2024).

Several limitations should be considered when interpreting the observed recovery. First, this was a single-patient case without a control condition, so functional improvement cannot be attributed exclusively to rehabilitation because antituberculosis treatment, resolution of hydrocephalus, VP shunting, spontaneous neurological recovery, and rehabilitation occurred concurrently. Second, the follow-up period was relatively short and did not establish long-term outcomes such as independent community ambulation, sustained bladder function, school participation, cognitive and developmental trajectory, or quality of life. These longer-term outcomes are important because pediatric TBM survivors may experience persistent motor, cognitive, hearing, visual, and other neurological sequelae (Huynh *et al*., 2022; du Preez *et al*., 2022; Igbokwe *et al*., 2023). Third, although serial clinical assessments documented changes in strength, transfers, standing, gait, ADLs, and bladder function, standardized multidomain outcome measures were not consistently recorded, limiting objective quantification of recovery. Then, current evidence remains insufficient to establish the optimal timing, intensity, dose, or modality of rehabilitation specifically for pediatric TBM (Alene *et al*., 2024; Gmelig Meyling *et al*., 2022; Linden *et al*., 2024). Therefore, the present findings should be interpreted as an encouraging clinical observation supporting individualized neurorehabilitation rather than evidence of treatment efficacy. Further prospective studies with longer follow-up and standardized multidomain outcomes are needed to establish evidence-based rehabilitation pathways for children surviving TBM.

Conclusion

This case describes progressive functional recovery following individualized neurorehabilitation in a child with tuberculous meningitis-associated hydrocephalus after ventriculoperitoneal shunt placement. Improvements were observed in lower-extremity strength, standing and gait ability, functional independence, and spontaneous urination.

Although these improvements cannot be attributed solely to rehabilitation because neurological recovery and neurosurgical management occurred concurrently, the clinical course suggests that early, individualized, function-oriented rehabilitation may support functional recovery after pediatric tuberculous meningitis. Further studies are warranted to investigate this hypothesis using standardized functional and developmental outcomes and longer follow-up.

Reference

Alene, K. A., Hertzog, L., Gilmour, B., Clements, A. C. A., & Murray, M. B. (2024). Interventions to prevent post-tuberculosis sequelae: A systematic review and meta-analysis. *EClinicalMedicine, 70*. https://doi.org/10.1016/j.eclinm.2024.102511

Chua, M. E., Yadav, P., Wang, P. Z. T., et al. (2023). 2023 Canadian Urological Association/Pediatric Urologists of Canada guideline: Pediatric patients with neurogenic lower urinary tract dysfunction. *Canadian Urological Association Journal, 17*(10), E338-E357. https://doi.org/10.5489/CUAJ.8390

du Preez, K., Jenkins, H. E., Donald, P. R., et al. (2022). Tuberculous meningitis in children: A forgotten public health emergency. *Frontiers in Neurology, 13*. https://doi.org/10.3389/fneur.2022.751133

Gmelig Meyling, C., Verschuren, O., Rentinck, I. R., Engelbert, R. H. H., & Gorter, J. W. (2022). Physical rehabilitation interventions in children with acquired brain injury: A scoping review. *Developmental Medicine & Child Neurology, 64*(1), 40-48. https://doi.org/10.1111/dmcn.14997

Huynh, J., Abo, Y. N., du Preez, K., Solomons, R., Dooley, K. E., & Seddon, J. A. (2022). Tuberculous meningitis in children: Reducing the burden of death and disability. *Pathogens, 11*(1). https://doi.org/10.3390/pathogens11010038

Igbokwe, V., Ruby, L. C., Sultanli, A., & Bélard, S. (2023). Post-tuberculosis sequelae in children and adolescents: A systematic review. *The Lancet Infectious Diseases, 23*(4), e138-e150. https://doi.org/10.1016/S1473-3099(23)00004-X

Linden, M. A., McKinlay, A., Hawley, C., et al. (2024). Further recommendations of the International Paediatric Brain Injury Society (IPBIS) for the post-acute rehabilitation of children with acquired brain injury. *Brain Injury, 38*(3), 151-159. https://doi.org/10.1080/02699052.2024.2309252

Madan, M., Sehgal, R., Tuli, I. P., Mehta, A., & Gera, R. (2023). Outcome of tuberculous meningitis in children aged 9 months to 12 years at the end of intensive phase of treatment. *Indian Journal of Tuberculosis, 70*, S104-S115. https://doi.org/10.1016/J.IJTB.2023.05.007

Meyling, C. G., Verschuren, O., Rentinck, I. C. M., Wright, F. V., Gorter, J. W., & Engelbert, R. H. (2023). Development of expert consensus to guide physical rehabilitation in children and adolescents with acquired brain injury during the subacute phase. *Journal of Rehabilitation Medicine, 55*. https://doi.org/10.2340/jrm.v55.12303

Nataprawira, H. M., Gafar, F., Risan, N. A., et al. (2022). Treatment outcomes of childhood tuberculous meningitis in a real-world retrospective cohort, Bandung, Indonesia. *Emerging Infectious Diseases, 28*(3), 660-671. https://doi.org/10.3201/eid2803.212230

Pakhan, A. A., & Raghumahanti, R. (2024). Targeted six-week intensive physiotherapy for a case of tuberculous meningitis with a syndrome of inappropriate antidiuretic hormone secretion. *Cureus*. Published online February 29, 2024. https://doi.org/10.7759/cureus.55214

Ryan, J. L., Zhou, C., Levac, D. E., et al. (2023). Gross motor change after inpatient rehabilitation for children with acquired brain injury: A 10-year retrospective review. *Developmental Medicine & Child Neurology, 65*(7), 953-960. https://doi.org/10.1111/dmcn.15471

Saal, C. L., Springer, P., Seddon, J. A., van Toorn, R., Esterhuizen, T. M., & Solomons, R. S. (2023). Risk factors of poor developmental outcome in children with tuberculous meningitis. *Child's Nervous System, 39*(4), 1029-1039. https://doi.org/10.1007/s00381-022-05791-2

Sager, C., Barroso, U., Netto, J. M. B., Retamal, G., & Ormaechea, E. (2022). Management of neurogenic bladder dysfunction in children: Update and recommendations on medical treatment. *International Brazilian Journal of Urology, 48*(1), 31-51. https://doi.org/10.1590/S1677-5538.IBJU.2020.0989

Suisan, Y. C., & Thohari, K. (2022). Comprehensive rehabilitation of severe tuberculous meningitis: A case series. *Surabaya Physical Medicine and Rehabilitation Journal, 4*(1), 32. https://doi.org/10.20473/spmrj.v4i1.29389

van Toorn, R., & Solomons, R. (2023). Diagnosis and management of tuberculous meningitis in children—An update. *Seminars in Pediatric Neurology, 47*. https://doi.org/10.1016/j.spen.2023.101071

Yiek, S. H., & Wong, A. S. H. (2022). Challenges and controversies in the management of tuberculous meningitis with hydrocephalus: A systematic review and Sarawak institution's experience. *Asian Journal of Neurosurgery, 17*(2), 189-198. https://doi.org/10.1055/s-0042-1750781

Zhang, X., Li, P., Wen, J., et al. (2023). Ventriculoperitoneal shunt for tuberculous meningitis-associated hydrocephalus: Long-term outcomes and complications. *BMC Infectious Diseases*. Published online 2023.