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Utilizing Errorless Learning as an Educational Intervention to Facilitate Independence with Functional Mobility Following a Stroke: A Case Report

Brenna Wetzel
University of Iowa

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Brenna Wetzel

DPT Class of 2018
Department of Physical Therapy & Rehabilitation Science
The University of Iowa

Abstract

Background & Purpose: Post-stroke memory impairments are not uncommon to see in post-acute neurological rehabilitation settings. Patients that present with these deficits have an increase in difficulty with learning new information or tasks and, as a result, limit their ability to gain independence prior to discharge. However, not all therapists are well familiar with a strategy called, errorless learning, that may be helpful in patients with memory impairments, and there is limited research on errorless learning within the stroke population. Thus, the purpose of this case report is to describe the implementation of an errorless learning plan and the positive outcomes, in terms of a patient's level of independence, with even surface transfers prior to discharge that may have resulted in part from this intervention. **Case Description:** The patient in this case report was a 59-year old male in a post-acute neurological skilled nursing facility (SNF) following a left-sided thalamic hemorrhagic stroke who needed moderate assistance with even surface transfers at the time of the initial evaluation. The patient showed difficulty with remembering the appropriate cues and steps for safe transfers, requiring him to need more physical assistance. **Intervention:** An errorless learning plan was implemented in an effort to improve his level of independence with even surface transfers. This plan consisted of step by step cues to tell the patient with each transfer that was completed throughout each day, including when working with other team members, every day of the week. No errors in the learning process were allowed within the completion of the transfer to prevent the brain from processing the wrong information. **Outcome Measures:** Even surface transfers were assessed weekly, over 7 weeks, by determining level of independence using a modified version of the Functional Independence Measure (FIM) scale. **Discussion:** After utilizing an errorless learning plan, the patient was able to achieve a level of supervision by his discharge date, needing no physical assistance from others. This result may indicate errorless learning may be beneficial to patients who demonstrate memory impairments post-stroke.

Keywords: Errorless learning; stroke; neurology; physical therapy; rehabilitation

Background

In the United States, nearly 800,000 people suffer a stroke each year[7]. It is not uncommon for those who have survived a stroke to develop memory problems, with roughly one-third of all people having memory difficulty post-stroke.[9] The impairments in memory can make learning new routines and movement patterns more challenging for the patient. If the patient is unable to retain the new information and implement it safely, their chances of returning home independently are decreased substantially.

There are typically two types of learning processes that physical therapists may use to assist patients in relearning new tasks and information: trial and error and errorless learning. Trial and error learning allows patients to test out the skill or try to recall information, with errors being acceptable in the learning process. The idea is a patient will learn from mistakes made with each attempt that can enhance knowledge and acquisition of information and skill. Feedback is given as needed to improve the performance for the next trial or set of trials prior to the next attempt, either extrinsically or intrinsically.[11] It has been found that trial and error learning may be most beneficial, in healthy individuals, with tasks that are complex, where many decisions are to be made, and when learning in a stressful environment.[11] Trial and error learning also works best when explicit memory is intact and the person is allowed to use their intrinsic error correction system appropriately.[4,13] However, the explicit memory may be hindered with someone suffering from a stroke, preventing them from having a well-functioning built-in error recognition and correction system to rely on. This is when the errorless learning process is most beneficial for people who have memory difficulties resulting from a stroke.

Errorless learning is a technique used to teach patients how to learn a new task or new information with the avoidance of errors throughout the learning process.[15] That is, tasks are broken down into simple steps and clear instructions or cues are provided to minimize error. The goal behind errorless learning is to prevent the brain from allowing an inappropriate or wrong thought or action to impede the learning process. The avoidance of inaccurate information processed prevents the opportunity for the brain to learn something incorrectly. It is unknown which tasks specifically that might benefit most from using an errorless learning approach versus trial and error.[10] However, it is thought that errorless learning would be most beneficial for tasks that trigger implicit memory.[4,13] Implicit memory is also known as unconscious memory or automatic memory, with a subset of implicit memory also known as procedural memory. Procedural memory is the storage of information regarding physical activities that can be performed without any conscious thought. This is the area of memory that physical therapists are often targeting during the rehabilitation process post-stroke. Therefore, implementing an errorless learning plan may help to make the learning process easier and assist the patient in becoming more confident in their routines.

However, there is limited information and studies on how errorless learning impacts a patient's ability to learn a full body movement task, requiring multiple steps for completion. Most studies have focused on learning different words or lists using recall or cues. There is little research on using errorless learning for functional mobility tasks, considering the impact on task retention or how an errorless learning plan could affect a person's level of independence. In other words, there is little information on how errorless learning can be translated into the clinical world of physical therapy and rehabilitation. In addition, there is very limited research on errorless learning specifically in people who had suffered a stroke. There were studies that looked at how errorless learning impacted people who had mild cognitive amnesia or a traumatic brain injury, but they did not limit it to just people with strokes. Therefore, the purpose of this case report is to describe the implementation of an errorless learning plan in a patient, who suffered a left-sided thalamic hemorrhagic stroke, with a focus on their ability to perform even surface transfers.

Case Description

The patient was a 59-year-old male who presented to a skilled nursing facility (SNF), specializing in neurological rehabilitation, following an acute left thalamic hemorrhagic stroke with a small intraventricular hemorrhage.

History

Initially, the patient was seen at his local hospital's emergency department (ED) after he had developed right-sided weakness and confusion; it is unknown how long his symptoms were present prior to his arrival. A diagnostic computed tomography (CT) scan revealed a left thalamic hemorrhage with a small intraventricular hemorrhage. He was then transferred from his local hospital to the Intensive Care Unit (ICU) of a near-by hospital for more specialized management of his injury. During the transfer, he had decreased level of consciousness and vomiting, requiring intubation and sedation. A repeat CT scan noted an enlargement of the left thalamic hemorrhage and increase in the intraventricular hemorrhage with an enlargement of the left frontal and temporal horns. He was extubated 6 days after the initial intubation period. The patient was able to follow commands to move the left upper and lower extremities, while his right side showed severe hemiplegia. Physicians documented the hemorrhage was likely related to uncontrolled hypertension. No surgical intervention was performed, but he was monitored for his ventriculostomy tube. An additional CT scan was performed, after extubation, and showed stability of his stroke. 18 days after admission to the second hospital, the patient was transferred to a local SNF, while awaiting on approval by insurance for placement into an acute inpatient rehabilitation setting. The patient stayed at the local SNF for 11 days until his insurance approved his stay at the acute inpatient rehab. Upon arrival to the acute inpatient rehab, the patient complained of blurred vision in his right visual field and numbness over his right side, but no tingling or pain. He required moderate to maximum assistance for activities of daily living (ADL's), transfers, ambulation and cognitive components including short term memory deficits and field of vision deficits. He had stayed in acute inpatient rehab for 5 weeks prior to his arrival at the SNF specializing in neurological rehabilitation.

Examination

Upon the patient's admission to the SNF specializing in neurological rehabilitation, the patient underwent a multitude of initial physical therapy assessments. Initially, the patient demonstrated passive range of motion (PROM) within normal limits of his left upper extremity and bilateral lower extremities. He had limited right upper extremity PROM due to pain and stiffness due to a sustained resting position of shoulder adduction, internal rotation, and elbow flexion. The patient demonstrated active range of motion (AROM) within normal limits of his left upper and lower extremities. He was unable to show any muscle activation of his right side, with the exception of his hip flexors, hip extensors, and knee extensors, presenting as 2-/5 to 2+/5 with formal manual muscle testing. The right upper extremity showed hypotonicity throughout as well as the right ankle, in which an OmoNeurexa shoulder brace and custom ankle-foot-orthosis (AFO) were used to prevent shoulder subluxation and foot drop, respectively. The left upper and lower extremities were consistently 4+/5 to 5/5 with manual muscle testing.

Sensation was decreased throughout the right upper and lower extremities, with absent sensation distally in the right hand and foot. The patient was independent with seated balance and needed minimum assistance with standing balance to avoid right knee buckling. He showed limitations in regards to functional mobility tasks. He was able to complete bed mobility tasks such as rolling and sit to supine to sit from the right side with moderate to maximum assistance for tactile cueing and physical assist with moving his right upper extremity and torso. He was contact guard assist to close supervision when completing these same tasks from the left. When transferring on even surfaces, the patient needed moderate assistance to safely and properly complete the appropriate steps to transfer to the next surface, with the physical therapist helping to move his lower trunk and hips. He also needed minimum assistance for his sit to stand transfer out of his wheelchair to, again, follow the appropriate cues and steps.

The patient had a manual wheelchair for mobility with longer distances, using his left upper and lower extremities to help propel himself, but still needed minimum assistance when propelling up hills or inclines. The patient was able to ambulate with the use a small quad cane and minimum assistance from the physical therapist, consisting of tactile and verbal cues to move his right hip into internal rotation and to prevent his right foot from catching behind him, creating a loss of balance.

The patient lives alone with minimal to no support readily available at home. His sister would be able to help once she was home from work, though the patient would likely spend the majority of his day alone. He was also close to potentially retiring soon, so returning to work was not influencing the discharge decisions. The patient's goals were to return his own home or his sister's home independently with the use of an assistive device.

While memory was not specifically assessed, difficulties with cognitive components of physical tasks were observed. For example, the patient needed a higher level of physical assistance to help perform even surface transfers, including bed to wheelchair transfers, shower transfers, and toilet transfers than might be expected based on his physical strength. He had the appropriate amount of strength on his unaffected side and some activation in his affected lower extremity to complete the transfer himself. However, he was lacking the cognitive ability to process the appropriate steps required for safe and independent transfers. When transfers were trialed, within the first two days upon admission to the neurological SNF, he seemed to forget the steps and move too quickly, requiring more assistance from a team member. Thus, after numerous trials of transfer training, it was decided that this patient was a good candidate for errorless learning strategies for even surface transfers based on objective findings throughout the physical and occupational therapy sessions. The errorless learning plan was used to promote a concrete and repetitive thought process to facilitate patient safety and efficient completion of the transfer, thereby promoting independence.

Intervention

The patient was seen by a physical therapist one time per day, Monday-Friday, for approximately 60 minutes per session. He was also seen by occupational and speech therapy throughout his stay. Physical therapy treatment included a range of activities such as transfer training, gait training, balance and proprioception training, wheelchair mobility training, and passive range of motion (PROM). However, to address the primary goal of returning to his home, a particular focus was placed on achieving independence with even surface transfers, which was a main limitation for safe discharge.

The errorless learning plan was created for even surface transfers after the initial assessment period. The errorless learning plan consisted of step by step instructions to be repeated the same way by each team member that interacted with the patient (Table 1). This plan was printed off and placed next to the patient's bed, next to the patient's toilet, and in the house staff's office where the rehab trainers, who assisted with the patients' daily routines, would meet throughout their shift. Every team member, including occupational therapy, speech, and residential staff members, were educated on what the errorless learning plan was and how it was to be implemented throughout the patient's day. This was carried out every day of the week with every transfer that the patient completed. In errorless learning, it is believed that it is vital to the patient's success that he was exposed to the same cueing with each transfer to help ensure the process was becoming more automatic and engrained into his implicit memory.

Table 1. Errorless Learning Plan implemented in the patient's care for the appropriate cues and sequencing for even surface transfer training.

1. Scoot hips to edge.
2. Line up feet.
3. Lean forward and push up. Catch balance in standing.
4. Grab helpers' elbow or shoulder.
5. Step towards surface, one step at a time. Catch balance in between each step.
6. When feet are even in front of new surface, reach back and slowly sit.

As he became more independent with his functional mobility and began improving his balance and gait mechanics, the need for the errorless learning plan was less prominent. The errorless learning plan also changed slightly as his progress improved by replacing step 4 (Table 1) with the patient grabbing his quad cane instead of a helper's arm or shoulder. As his level of independence improved and he appropriately carried out the correct sequence, the errorless learning plan was not used as often. This decreased the need of someone else to assist him. However, it was very important to correct the patient if he began completing the incorrect sequencing pattern for the transfer. If he began making a mistake, at that time, the therapist or team member was to stop the transfer process and begin again, so that the errorless learning plan could be implemented correctly. Again, in errorless learning, it is thought that it is important to stop the patient from practicing the wrong movement pattern, to prevent his brain from remembering the wrong pattern and creating an inappropriate habit. This could impair his ability to reach his goal of discharging home independently with the use of an assistive device.

Outcome

The primary outcome measure used was a modified version of the level of functional independence scale taken from the Functional Independence Measure (FIM) (Table 2).[5,14] While there is no research to determine the validity of the modified version of the FIM scale measurement tool; it is presumed that the modified version is similarly reliable and valid as the original version for this case as it is still assessing functional levels. The MCID for the original FIM scale for the total score is 22 points, for the motor subscale is 17 points, and for the cognitive subscale is 3 points.[6] Each level is scored from 1-7 points, with a higher score representing the more independent the patient is. However, the full FIM scale was not used and neither was the motor subscale, as just the even surface transfers were assessed. Progress reports were due weekly to the patient's insurance, allowing for him to show more progress over a greater amount of time than daily progress notes. Re-evaluation of the goals and level of independence of the patient were reassessed by clinical judgement of the treating physical and occupational therapist within the weekly progress reports. The main functional mobility tasks that were the focus of this case report were the bed to wheelchair transfers, shower chair transfers, and the toilet transfers. The patient's progress after implementing an errorless learning plan is listed in Table 3.

Table 2. Modified Level of Functional Independence Scale taken from the Functional Independence Measure.

Independent	All tasks are performed safely without modification, assistive devices, or aids, and within reasonable time.
Modified Independent	Activity requires any one more of the following: an assistive device, more than reasonable time, or there are safety (risk) considerations.
Supervision	Subject requires no more help than standby, cueing or coaxing, without physical contact or helper sets up needed items or applies orthoses.
Contact Guard Assistance	One or two hands on subject's body, but provides no other assistance to perform the functional task.
Minimum Assistance	With physical contact the subject requires no more help than touching, and subject expends 75% of more of the effort.
Moderate Assistance	Subject requires more help than touching, or expends half (50%) or more (up to 75%) of the effort.
Maximum Assistance	Subject expends less than 50% of the effort, but at least 25%.
Total Assistance or Not Testable	Subject expends less than 25% of the effort or unable to perform.

Table 3. Patient's progress and improvement with even surface transfers after implementing an errorless learning plan.

	Even Surface Transfers	*Toilet Transfers*	*Shower Chair Transfers*
Initial Assessment	Moderate Assistance	Moderate Assistance	Minimum Assistance
End of Week 1	Minimum Assistance	Moderate Assistance	Minimum Assistance
End of Week 2	Contact Guard Assistance	Minimum Assistance	Contact Guard Assistance
End of Week 3	Contact Guard Assistance	Contact Guard Assistance	Contact Guard Assistance
End of Week 4	Supervision	Supervision	Supervision
End of Week 5	Supervision	Supervision	Supervision
End of Week 6	Supervision	Supervision	Supervision
End of Week 7	Supervision	Supervision	Supervision

In the future, errorless learning plans could be implemented for each component of the FIM to see the global effects on function. Because we only applied an errorless learning plan to the even surface transfer component of functional mobility, it's difficult to assume how an errorless learning plan would affect other components of functional mobility, either improving or hindering each task. This is an area that could be further explored in future cases or research studies.

Discussion

The purpose of this case report was to describe the implementation of an errorless learning plan for a specific functional task in a patient, who had suffered a left-sided thalamic hemorrhagic stroke, and how the plan may have allowed for improvement in the level of independence with even surface transfers prior to discharge. The use of consistent cueing and multiple repetitions may have contributed to the initial rapid improvement in transfer independence to needing only supervision, but with no physical assistance. The high level of repetition helped the patient's transfer to become more automatic and engrained into his implicit memory. Due to the possible discharge locations, at home independently or at his sister's home, it was expected to get him as independent as possible as he would be spending time alone with minimal to no assistance from others. By the time discharge occurred, the patient was at the level of supervision for even surface transfers. Initially, it was believed that he could have improved to a level of modified independent with the use of a small based quad cane if his insurance allowed for more time with rehab; however, he was not able to reach a higher level of independence better than supervision. Also due to the patient making more functional improvements in walking with a small based quad cane, the toilet transfers and shower bench transfers were not as prominent towards the end of his stay as he no longer needed to complete a transfer from one even surface to another. He was able to walk from his room to the shower room and bathroom without the use of a wheelchair, therefore, he did not need to complete the same cueing and steps as from his wheelchair to his bed. However, he was still using his wheelchair for longer distances, requiring him to apply his step by step cues to transfer from his wheelchair to his bed or another level surface. This case serves as an example of how to apply errorless learning to a physical function task as opposed to a memory task as is more commonly studied in the literature. Although it is only theorized, preventing errors in the learning process of a physical task may allow for the correct steps to be carried out more efficiently and without introducing the brain to incorrect information.

The full 18-item FIM outcome tool could have been used to show the overall improvement in functional independence regarding a variety of tasks; however, the focus of implementing the errorless learning plan was on even surface transfer training. Using, the 18-item FIM would allow for a better correlation to see how the progress changed over time and how meaningful the change was to the patient's outcome. It would also allow to show how implementing errorless learning plans impact a variety of functional tasks throughout the patient's daily routine.

This patient had suffered from a left thalamic hemorrhage in addition to a small intraventricular hemorrhage. With thalamic strokes, it is not uncommon for patients to have post-stroke dementia. A variety of memory impairments may present depending on each person's injury, including anterograde memory impairment, delayed recall deficit, and learning and delayed recall in visuospatial and verbal tasks.[1] As it is known, the thalamus has many nuclei that are involved with a variety of different pathways. It's important to know which nuclei play a role in memory processing to determine the effects of a stroke in this area. According to one study, when the mammillothalamic tract and mediodorsal nucleus are involved in the stroke, the memory impairments are more prevalent.[2] If the mammillothalamic tract is more disrupted, then the memory impairment is more severe than when mediodorsal nucleus is damaged; however, memory impairment is still present with both structures affected.[2] There is limited research on what thalamic nuclei are specifically involved with explicit memory and implicit memory; however, these pathways are extremely complex with a variety of structures involved, leading to difficulty narrowing down which structures will impact each part of memory, respectively. With this patient, it was unknown specifically what structures were involved with his left thalamic hemorrhagic stroke, so it's difficult to say what memory impairments were greatly affected. Regardless of not knowing what specific memory structures were involved, it didn't change how the patient was evaluated in rehab. The evaluation was still tailored to determine what his objective impairments and limitations were. Throughout the first couple of days working with him, it was apparent that he was having difficulty remembering the appropriate cues to transfer from surface to surface. Because he could not remember what information the staff had told him, it was decided to trial an errorless learning plan to determine if this would be more beneficial. In this patient's case, it was.

The idea of errorless learning and the prevention of errors throughout the learning process is important; however, so is the idea of many repetitions, which is also needed for errorless learning to be successful. As stated previously, the patient received the same cues and steps with every transfer and by every staff member to help the task become more automatic and stored in his implicit memory. According to one study, implicit and explicit memory tasks are strengthened with multiple repetitions more so than they are with a single repetition.[3] It is difficult to say specifically how many repetitions are needed to store information for implicit memory; however, in animal studies, researchers say 400-600 repetitions per day can help to change wiring and networks in the brain to store the new information or tasks.[8] This may not be feasible for the real-world, but it's important to take away the idea that many repetitions are needed to induce adaptation. This type of practice with multiple repetitions is called massed practice.[8] Along with multiple repetitions, it is also important to consider the quality of repetitions.[12] Concentrating on the task and being mindful of what is being carried out also helps to enhance the changes within the brain.[12] These two ideas of learning help to reinforce what errorless learning is and how to implement it with patients, making sure they are exposed to the information multiple times throughout the day, as well as focusing on the avoidance of errors as the task is being carried out to ensure proper learning and storage of information.

Although there were improvements in the patient's level of independence with even surface transfers, there were still limitations that need to be considered when deciding to implement an errorless learning plan as an intervention. It's difficult to ensure each staff member is following the errorless learning plan as it had been described because it's not possible to be with the patient for every transfer. Along those same lines, it's challenging to determine if every staff member is saying the correct steps and cues the exact way that it is written in the plan. The patient may forget to follow the correct steps and the staff members don't have a chance to begin the errorless learning plan or correct the patient prior to them initiating the movement. The patient may also have had memory processing difficulties prior to the stroke which would impact their ability to learn and retain new information or skills when completing rehab. Finally, a limitation of this case report is that there was no documentation of what specific memory impairments this patient may have had after the stroke. Explicit memory is not always impacted when someone suffers a stroke; therefore, using errorless learning may not always be a superior choice to trial and error learning due to the patient correctly being able to use their internal error-correction system, allowing for errors to assist in retaining the appropriate information and tasks.[13]

Despite there being a fair amount of research on errorless learning for memory and how it affects specific populations of people with memory deficits, there is very limited research on applying errorless learning for functional tasks in a specific stroke population, and its ability to promote patient independence. As there are many areas that are yet to be researched, it translates into a lack of clinical application and clinical research to support what is being done in the neurological rehabilitation facilities. Thus, this case provides one example of the use of errorless learning in transfer training for a stroke patient. Future studies would be beneficial to help relate what we know about errorless learning into the physical therapy setting by using controlled designs to determine its true effectiveness for functional task learning.

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