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Feasibility of Using Erigo and Lokomat in Rehabilitation for Patient in Vegetative State: A Case Report

Rusek W[1], Adamczyk M[1,2]*, Baran J[1,3], Leszczak J[1,3] and Pop T[3]

[1]Department of Medicine, Rehabilitation Centre Rehamed-Center, Tajęcina, Poland
[2]Department of Medicine, RehaKlinika, Rzeszów, Poland
[3]Faculty of Medicine, University of Rzeszów, Poland

Abstract

Objective: The rehabilitation of a patient recovering from a coma is a serious challenge in clinical practice. The aim of this study was to present the feasibility of using modern devices in rehabilitation for a patient in a vegetative state.

Case report: The studies involved a 48-year-old female patient who at the age of 47 suffered an intracerebral haemorrhage. The patient, for 12 months, was in the stationary ward, and from Monday till Friday underwent a rehabilitation program including individual therapies, Erigo and Lokomat. A functional study included: measurements of the passive range of motion of the upper and lower limbs, angle of catch, the Modified Ashworth Scale and the Glasgow Coma Scale.

Results: Proposed treatment had an impact on reducing the severity of the coma, improving the range of motion, decreasing the angle of catch, spasticity reduction and the patient's independence in terms of maintaining the head while sitting.

Conclusion: The combination of Erigo and Lokomat with conventional therapy, in the case of patients in the vegetative state, allows the maintenance of proper ranges of motion, prevention of oedema, maintenance of proper limb circumferences, improvement of orthostatic reactions and reduction of spasticity.

Keywords: Vegetative state; Rehabilitation; Robot-enhanced procedures

Introduction

The continuous development of technology in the field of medicine enables patients after severe brain damage to be saved and maintained. Therefore, it was necessary to distinguish states in which there are serious disturbances of consciousness, but life functions are preserved. In-depth research is being conducted around the world to clarify problems related to diagnostics, treatment methods and prognosis in patients with impaired consciousness. A state of consciousness is defined as the ability to receive record and process information and to display adequate responses. Consciousness disorders are more difficult to characterize, as evidenced by the many terms used for different states of consciousness by different researchers. Such terms include, among others: a state of minimal consciousness, a vegetative state or a coma. Many of these terms may mean different things to different people, but it is nevertheless appropriate to define them as closely as possible [1]. For patients who show signs of reaction, such as imitation, visual tracking of objects, or the ability to answer yes or no using gestures, a diagnostic category has been created called a state of minimal consciousness. Such patients inconsistently perform one-step commands and have the ability to locate harmful stimuli. This is different to a vegetative state, wherein patients retain the ability to function while lacking sensations and thoughts. In addition, in this condition, the occurrence of a cycle of sleep and wakefulness, manifested as spontaneous eye opening, can be observed. Coma, on the other hand, is defined as a state of unconsciousness in which the patient demonstrates a lack of response to stimuli or a minimal response and no sleep and wakefulness cycles are observed. The eyes remain closed and there is no motor function other than primitive reflexes [2,3].

Studies published so far concerning the prognosis and possibilities of recovery of patients in a vegetative state and minimal consciousness are not very optimistic. The treatment of people with impaired consciousness depends on the underlying reason that caused them. Initially, medical staff mainly focuses on securing the proper operation of the respiratory and circulatory systems to maximize the amount of oxygen reaching the brain. Non-pharmacological interventions for patients with consciousness disorders involve the use of sensory stimulation techniques and physical therapy, which aim to both prevent complications (i.e., contractures or pressure ulcers) and support the recovery of lost functions [3,4]. A review of the literature shows that most cases of regaining consciousness occur within the first 3 months after non-traumatic brain injury. After traumatic injury, patients can regain consciousness within 12 months. The prognosis and results of treatment depend on the reason causing the coma, the patient's age and comorbidities, the quality of medical care and the intensity of rehabilitation [3,5].

Normal, repeated patterns of movement are an important factor conditioning the neuroplasticity of the human nervous system. Robotic neurorehabilitation devices have been developed precisely to enable repetitive motor training of patients with large deficits [6]. The first device that can be introduced at an early stage of verticalization is the Erigo verticalization table. It is a specialized therapeutic table for the verticalization of neurological patients, enabling cyclic loading with simultaneous lower limb movements. This counteracts the negative effects of a sharp drop in blood pressure caused by prolonged lying

***Corresponding author:** Adamczyk M, Department of Medicine, Rehabilitation Centre Rehamed-Center, Tajęcina, Poland, Tel: +48695930193; E-mail: marzenaadamczyk91@gmail.com

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down. It allows the patient to stand upright and simulate walking movements through an electronic actuator system. A system that stimulates the reflexes of physiological walking enables early mobilization and effective therapy of patients with neurological and circulatory disorders [7]. Another device is the Lokomat, which allows rehabilitation in conditions of dynamic relief while maintaining the correct walking pattern performed on a treadmill. Regular training with the use of Lokomat allows the prevention of pathological patterns in people with neurological diseases. Thanks to the use of a sensor system placed in orthoses and specialized computer software, the patient is able to perform correct and repeatable gait cycles. The device consists of a treadmill integrated with a dynamic support system, fully robotic orthoses that cooperate with them, and a device control system [6]. The aim of the study was to present the possibilities of using modern devices as a supplement to the patient's rehabilitation process in a vegetative state after non-traumatic intracerebral haemorrhage.

Case Presentation

The paper describes the case of rehabilitation in a 48-year-old patient who suffered a non-traumatic intracerebral haemorrhage at the age of 47. The patient was taken to the Hospital Emergency Department, due to loss of consciousness at home, in a very severe condition, unconscious. It is known from family reports that she had previously reported severe headache. On admission, in physical examination, both pupils were dilated and there was no reaction to light. Computed tomography of the brain showed diffuse oedema and subdural bleeding with displacement of the centre line. On the same day, left-sided craniectomy was performed, the subdural hematoma removed, and the left middle cerebral artery aneurysm was clipped. In the anaesthesiology and intensive care unit, several attempts were made to extubate the patient, but she did not attempt to breathe on her own. Ten days after surgery, a tracheostomy tube was inserted. A CT scan performed two weeks after the operation showed a 110 × 53 mm malacic-oedema area in the frontal temporal region of the left cerebral hemisphere, a similar change of 55 × 35 mm in the left occipital lobe and of 30 × 14 mm in the right frontal lobe. There was also a displacement of the central brain structures to the right by 5 mm and a dilation of the ventricular system of the brain. Due to secondary hydrocephalus, it was decided to insert a ventriculoperitoneal valve into the corner of the right-side lateral ventricle. Control tomography showed narrowing of the ventricular system. One month after the craniectomy, a free bone lobe from the abdominal wall was used to restore the loss in the skull. In the following weeks the patient's condition stabilized, but she remained in a coma. Two months after the incident, she was rated 3 on the Glasgow scale and discharged from the hospital.

Upon admission to the Rehamed-Center, the patient's vital functions were normal, and she was breathing on her own through a tracheostomy tube. A physiotherapeutic examination was performed, during which in the patient was found:

- Four-limb spastic paralysis,
- Lack of motor activity,
- Lack of head and torso control in any position,
- Increased muscle tension in the distal body parts (greater on the left side),
- Tendency to strain,
- Positive Babinski's symptom on the left side,
- Right foot reflection for plantar reflex testing,
- Restrictions on the mobility of some upper and lower limb joints,
- Lack of adaptation of the circulatory and respiratory system to sitting and standing positions,
- Lack of reaction to contact attempts,
- Gagging during swallowing attempts,
- Total dependence on others during bed turns, transfers and everyday activities.

In addition, a medical examination showed: left eye pupillary unresponsiveness, L <R corneal reflexes, features of damage to the III left cranial nerve (drooping of the eyelid, dilated pupil) and lack of reaction in the Baniewicz test. The patient's condition was defined as deep coma. In control head tomography, hypodense zones (probably hypoxic-ischemic changes) were found in the peripheral parts of the left hemisphere of the brain. A separate hypodense focus of a similar nature, 6 mm in diameter, was also visible in the left thalamus. Supratentorial ventricular system asymmetrically enlarged in the area of the left side chamber slightly displaced to the left side. Hypocerebrally, hypodense areas oppressing the brain surface on both sides of the frontal area (to a greater extent on the left side). The patient's vital functions were continually monitored, and frequent desaturations below 80% were observed in the first days of stay. Based on the laboratory tests, urinary tract infection was also diagnosed, and empiric antibiotic therapy was used, followed by targeted therapy with good results. After functional diagnostics, an improvement program was planned, which included:

- Stretching spastic muscle groups, restoring normal muscle tension, applying joint pressure (approximation) in contracted joints: performed three times a day during 45-minute individual therapies with a physiotherapist,
- 45 minutes upright standing on an Erigo table with a walking function,
- Lokomat therapy three times a week (implemented after seven months of stay).

In order to assess the effects of the improvement program used, objective research was carried out before its implementation. Goniometric measurements of the passive ranges of upper and lower limbs were made, angle of catch of the left elbow joint was determined, spasticity of the lower limbs was assessed using the modified Ashworth scale, the time of independent maintenance of head and torso in a sitting position was measured, and the degree of consciousness was assessed using the Glasgow scale. All tests were performed four times: before therapy, after 4, 8 and 12 months.

Results

After four months of rehabilitation, the patient's left eyelid lift and better eye movement were observed and noted. It has been observed that the patient periodically opens her eyes and moves them to follow something. In addition, the appearance of spontaneous unintentional movements in the second and third fingers of the right hand was noted. This motor activity, although it gradually increased, never reached the level of intentional movement. Medical examination showed that the patient's condition no longer has the features of a coma and can be described as a vegetative state. Goniometric measurements of upper and lower limb movement ranges performed before therapy showed mobility limitations in some joints. After the therapy, i.e., after twelve months, the ranges of the tested movements were close to normal. The values of movement ranges in joints with limited mobility are presented in Tables 1 and 2.

Prior to therapy, a goniometric measurement of the angle of catch of the left elbow joint showed spasticity occurring in a 50° flexion movement. After the improvement process, it was 90° (Table 3). A modified Ashworth scale was used to assess spasticity. Initially, the muscular tension of the lower extremities was assessed at 4 points, while after the rehabilitation was completed, a reduction in spasticity to 3 points was obtained (Table 4). Measurements of the time maintaining head and torso in a sitting position taken before therapy showed an inability to maintain them independently. After the end of therapy, i.e., after twelve months, the patient was able to independently maintain her head for 30 seconds and the torso for 15 (Table 5). The severity of coma was assessed using the Glasgow scale. At the beginning of the improvement process, the patient obtained 3 points out of 15 possible. After four months of rehabilitation, the patient obtained 4 points on the Glasgow scale and this result was maintained until the end of her stay (Table 6). Analysis of reports on the Lokomat therapy showed that the patient's initial gait training lasted a much shorter time than those at the end of the rehabilitation process. It also translated into a gradual extension of the distance covered (Table 7).

Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
Flexion of the shoulder joint	30°	55°	90°	100°
Flexion of the elbow joint	45°	70°	85°	110°
Wrist extension	-20°	20°	45°	60°

Table 1: Change in the range of motion of the upper left limb.

	Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
Lower left limb	Flexion of the hip with bent knee	45°	65°	80°	90°
	Abduction of the hip joint	10°	10°	15°	20°
	Dorsiflexion of the foot	-30°	-15°	0°	10°
Lower right limb	Flexion of the hip with bent knee	55°	75°	90°	100°
	Abduction of the hip joint	10°	25°	30°	35°
	Dorsiflexion of the foot	-25°	-5°	10°	20°

Table 2: Change in the range of motion of the lower limbs.

Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
AOC	50°	70°	80°	90°

Table 3: Change in the AOC of the left elbow joint.

Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
Modified Ashworth scale	4	4	3	3

Table 4: Change in muscle tension in the lower extremities on a modified Ashworth scale.

Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
Time of maintaining head in a sitting position [s]	0	10	25	30
Time of maintaining torso in a sitting position [s]	0	0	5	15

Table 5: Change in the duration of the maintenance of head and torso in a sitting position.

Measurement	Before rehabilitation	After 4 months	After 8 months	After 12 months
Glasgow scale	3	4	4	4

Table 6: Change in severity of coma on the Glasgow scale.

Measurement	During the first training	After 2 months	After 4 months	After 6 months
Duration of walking on Lokomat [min]	15	18	32	40
Average distance covered while walking on Lokomat [m]	162	208	309	358
Average walking speed during training on Lokomat [km/h]	0.5	0.5	0.5	0.5

Table 7: Change of gait parameters during therapy on Lokomat.

Discussion

Most studies on the effects of treating patients with impaired consciousness are based on case reports or are retrospective studies. There are no large, randomized trials of efficacy in patients with impaired consciousness, and therefore there are no evidence-based approach guidelines. Further research can therefore provide information on treatment and rehabilitation as well as expand knowledge of brain plasticity. Therefore, currently, the huge challenge is to determine the mechanisms by which some patients may regain consciousness [3]. The ongoing discussion about the possibility of curing patients in a vegetative state, unfortunately, does not bring any specific conclusions. According to a group of researchers from Multi-Society, patients with non-traumatic lesions such as hypoxia or ischemia have a much worse prognosis than those after trauma. They considered 169 adult patients in a vegetative state, of which 11% regained consciousness after three months, two patients regained consciousness within six months, 12% a year after injury, 28% remained vegetative, and 48% died. Of those 15% of patients who regained consciousness, only one of them returned to fitness [5].

Based on various reports, it can be concluded that patients in a vegetative state regain consciousness usually between 4 and 33 months after non-traumatic brain injury. Researchers' conclusions regarding the mechanism of healing and its diagnosis are also different. Sara et al. described the case of a patient in whom they observed the appearance of emotional reactions and gradual recovery of motor skills. Ford et al. only observed an improvement in the patient's reactivity to auditory or visual stimuli, and Fellerhoff et al. showed a motor improvement in oral feeding. Researchers used various tools to measure results, including the Glasgow scale, Functional Independence Measure (FIM), and cognitive tests. Most authors found that various therapeutic measures can help in the recovery of the patient, e.g. drugs such as intrathecal baclofen, experimental immunological therapy, the use of heated air for ventilation. However, some authors hypothesized that patients in a vegetative state may have had spontaneous brain changes (axonal regrowth or neurochemical changes induced by seizures) [8-10].

The analysis of the described case showed that the Erigo rehabilitation program implemented in the first four months enabled improvement of the vascular response during verticalization. The introduction of Lokomat to the rehabilitation program in the seventh month allowed reduction of spasticity and consolidated the effects of recovering the correct ranges of movement. Frequent keeping of the patient in a vertical position and passive stimulation of gait using a stationary exoskeleton enabled the patient to maintain her torso and head in a sitting position for several dozen seconds. Patients in a vegetative state have a complex and highly individualized number of psychomotor disorders, therefore their rehabilitation is a huge challenge for doctors and physiotherapists. These patients have memory deficits, serious emotional disorders and loss of communication skills, which further hinders recovery [11].

Conclusion

The implemented rehabilitation program resulted in a decrease in spasticity as well as improvement of limited ranges of movement. Incorporation of Lokomat into conventional therapy of patients in a vegetative state after non-traumatic intracerebral haemorrhage is possible and brings beneficial effects. The use of comprehensive rehabilitation in patients in a vegetative state allows maintenance of normal ranges of peripheral joint movement, prevents swelling, improves orthostatic reactions and reduces spasticity.

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