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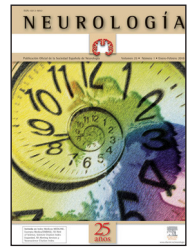

REVIEW ARTICLE

Neuro-rehabilitation after stroke

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Abstract
Introduction: The high incidence of stroke results in significant mortality and disability leading to immense health care costs. These costs lead to socioeconomic, budgetary, and staffing repercussions in developing countries. Improvements in stroke management focus mainly on acute neurological treatment, admission to stroke units, fibrinolytic treatment for ischaemic strokes and rehabilitation processes. Among these, rehabilitation has the longest therapeutic window, can be applied in both ischaemic and haemorrhagic strokes, and can improve functional outcomes months after stroke.
Development: Neurologists, because of their knowledge in neuroanatomy, physiopathology, neuropharmacology, and brain plasticity, are in an ideal position to actively participate in the neurorehabilitation process. Several processes have been shown to play a role in determining the efficacy of rehabilitation; time from stroke onset to rehabilitation admission and the duration and intensity of treatment.
Conclusions: Neurorehabilitation is a sub-speciality in which neurologists should be incorporated into multidisciplinary neurorehabilitation teams. Early time to rehabilitation admission and greater intensity and duration of treatment are associated with better functional outcomes, lower mortality/institutionalisation, and shorter length of stay. In order to be efficient, a concerted effort must be made to ensure patients receive neurorehabilitation treatment in a timely manner with appropriate intensity to maximize patient outcomes during both inpatient and outpatient rehabilitation.

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PALABRAS CLAVE
Ictus;
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Neurorrehabilitación tras el ictus

Resumen
Introducción: La enfermedad cerebrovascular o ictus es uno de los motivos más frecuentes de asistencia neurológica urgente, representa una de las primeras causas de muerte e invalidez en los adultos y supone un enorme coste tanto humano como económico. Los avances en el tratamiento del ictus tienen como ejes fundamentales la atención neurológica precoz, el ingreso en las unidades de ictus, la aplicación del tratamiento fibrinolítico en el infarto cerebral y el tratamiento rehabilitador. Entre los diferentes tratamientos, la neurorrehabilitación presenta una ventana terapéutica más amplia, puede aplicarse tanto en ictus isquémicos como hemorrágicos y puede mejorar el pronóstico funcional incluso meses después del ictus.
Desarrollo: El neurólogo, por sus conocimientos en neuroanatomía, fisiopatología, neurofarmacología y los procesos de plasticidad cerebral, está en una posición ideal para participar activamente en la neurorrehabilitación. En el proceso de rehabilitación hay una serie de factores que condicionan su eficacia; el tiempo hasta el inicio de la rehabilitación, su duración y la intensidad del tratamiento.
Conclusiones: La neurorrehabilitación es una subespecialidad en que el neurólogo puede formarse con el fin de participar en los equipos multidisciplinarios que dirigen el proceso de neurorrehabilitación. El inicio precoz del tratamiento y su intensidad y duración adecuadas conllevan mayor recuperación funcional y menores mortalidad, tasa de institucionalización y estancia hospitalaria. Es imprescindible realizar un esfuerzo de planificación para que los pacientes puedan beneficiarse de un tratamiento neurorrehabilitador específico iniciado precozmente, con la intensidad necesaria y de forma continuada durante el ingreso y posteriormente de forma ambulatoria.

Introduction

Cerebrovascular disease or stroke is one of the most frequent reasons for emergency neurological care, representing one of the leading causes of death and disability in adults and entailing significant human and economic costs. A recent prospective study has determined that the gross incidence of stroke in the population over 18 is of 174 cases/ 100,000 inhabitants and year[1], and gradually increases with age[2-6]. The prevalence rates adjusted by age are 7.3% for males, 5.6% for females and 6.4% for both genders together[6]. In Spain, stroke represents the second leading cause of death after ischemic cardiopathy and is the leading cause of death by specific entities in females[7].

According to the World Health Organization (WHO), stroke represents the leading cause of physical disability in adults and the second of dementia[8]. In the Survey on Disabilities, Deficiencies and Health Status (National Statistics Institute, 1999)[9], it was noted that in 13% of dependent people, the dependence was caused by cerebrovascular disease; of those, one-third had a moderate degree of dependence, 50% and severe dependence and 16%, absolute dependence.

Moreover, stroke is estimated to consume 3-4%of health expenditures in developed countries, and over 70% of direct first-year health care costs occur during hospitalisation[10-12]. Given the progressive aging of the population and that three-quarters of strokes occur in patients over 65, an increase is expected in its incidence in the coming years[8].

Fundamental elements in advances in stroke treatment include early neurological care, admission to stroke units, application of fibrinolytic therapy on cerebral infarction and rehabilitation treatment[13]. Of these, rehabilitation treatment has a wider therapeutic window, it may be applied in both ischemic and haemorrhagic stroke, it improves functional outcome even several months after the occurrence of the stroke and it reduces the costs associated with the disease.

Stroke rehabilitation

Rehabilitation is a time-limited process, which aims to prevent complications and reduce neurological deficit to achieve the maximum possible functional capacity to facilitate personal independence and family and work reintegration. Rehabilitation should start early and in a coordinated manner and be maintained during the different healthcare stages[14].

After the acute phase, neurorehabilitation represents the only chance of improvement for patients with residual disability after stroke; and, in contrast to fibrinolysis, it is estimated that the former could be applied in about 40%of all stroke cases (ischemic and haemorrhagic)[15]. Neurorehabilitation has been defined as the set of methods that aims to restore neurological function lost or impaired due to brain or spinal cord injury. In patients who have suffered a stroke, the methods used in neurorehabilitation exploit brain plasticity to improve or normalise neurological and functional deficits.

In recent years, neurorehabilitation has emerged as a subspecialty with extraordinary growth potential, important clinical applications and promising avenues of research, in which the neurologist should become involved[16]. Neurologists, through their knowledge of neuroanatomy, pathophysiology, neuropharmacology and brain plasticity processes, are in an ideal position to participate actively in neurorehabilitation and collaborate in developing new and more effective techniques to improve motor control and cognitive skills after a stroke. Indeed, in some countries there are already neurorehabilitation training programmes that neurologists with a special interest in this field take. Just as specialisation in endovascular techniques enables neurologists to participate actively in specific aspects of the care of patients who have suffered a stroke, neurorehabilitation training will also enable the physicians to become actively involved in functional recovery processes.

Patients with disability due to stroke have to have access to a multidisciplinary rehabilitation team that addresses neurological dysfunction as a whole, trying to improve all affected areas. This team may be composed of physicians specialising in neurorehabilitation, physiotherapists, occupational therapists, speech therapists, neuropsychologists, orthotists, nursing staff and social workers.

It is essential to estimate the functional objectives for each patient and schedule the appropriate treatment interventions that are relevant and effective in line with those objectives[14,17]. The recovery process must be re-evaluated periodically and, if necessary, re-adjusted to the current situation.

Phases and areas of assistance in the rehabilitation of stroke patients

1. Hospitalisation in acute phase. Rehabilitation treatment should be started early and be integrated into organised assistance such as the stroke unit. In the acute phase, the most appropriate referral should be planned for each patient, bearing hospital discharge in mind: specific hospital rehabilitation services, outpatient rehabilitation services, home care and medium or long-stay centres. Once the patient is medically stable, the multidisciplinary rehabilitation plan by objectives should be started[14,18].
2. Rehabilitation areas in subacute phase[18,19]. At this stage, depending on the patient's clinical situation and/or social development, the rehabilitation process can be carried out in the following ways:

—Hospital rehabilitation. For individuals with moderate or severe disability in two or more functional areas, who require nursing care and have medical and cognitive conditions that allow them to participate in high intensity therapies with the aim of overcoming the disability and returning to their normal environment.
—Outpatient rehabilitation. Patients without significant cognitive deficits, with mild or moderate disabilities in one or two functional areas, with adequate social and family support and with the possibility of travelling to the rehabilitation service.
—Home care. Suitable for patients with moderate-severe disability and enough family support to remain at home, with problems in travelling to the rehabilitation service.
—Medium or long-stay residence or centre. Individuals in a situation of disability for daily activities, unable to tolerate intensive treatment and without sufficient family and social support to foresee a return to their home in the medium term.

Modifiable factors that influence the post-stroke rehabilitation process

The objective of neurorehabilitation is to improve the disability of patients so as to enable them to be reintegrated, and in the best terms, to their personal, working and social life. There are a number of modifiable factors that strongly influence the functional recovery of patients who have suffered a stroke, among which are: time of onset of rehabilitation, duration and intensity of treatment and location where it is received.

Time until the beginning of treatment

Despite the recognition of rehabilitation as one of the main factors for functional recovery after a stroke, one of the main challenges is being able to include patients in rehabilitation programmes at the appropriate time[20]. Several studies in experimental models on the neurobiological mechanisms involved in neurological recovery after stroke indicate that there is a short period during which the recovery process is especially favoured and the response to the rehabilitation treatments can be maximum[21,22]. A delay in starting treatment is associated with decreased cortical reorganisation and reduced chances of achieving adequate functional recovery[22-25].

To ascertain what the best time to begin rehabilitation treatment could be, Biernaskie et al.[26] submitted 3 groups of rats with cerebral infarctions to 5 weeks of rehabilitation; treatment was initiated 5 days after the stroke in one group, 14 days after the stroke in another, and on the 30th day in the third, while a fourth group was untreated (control group). The animals that began rehabilitation on the fifth day after the stroke presented a marked improvement

compared to the group that started after 2 weeks (which also showed differences with respect to the control group). There were no significant differences when comparing the degree of neurological recovery between the group of animals that started treatment within 30 days of the stroke and the control group without rehabilitation.

The associations between delay in starting treatment and worse functional outcome, as well as between early treatment and better prognosis, have also been highlighted in patients who have suffered a stroke[27-30]. Maulden et al.[31] examined the effect of delaying the start of rehabilitation in nearly a thousand patients who had suffered a moderate or severe stroke. Regardless of stroke severity, starting rehabilitation early was significantly associated with better functional outcome at discharge and higher scores on basic activities of daily living (ADL) scale and the FIM (Functional Independence Measure). In addition, the length of hospital stay was shorter in patients with moderate stroke and early start of rehabilitation. Later, in a retrospective study that included 435 patients, Salter et al.[32] found that, regardless of baseline clinical condition, the group of patients who had begun rehabilitation in the first 30 days post-stroke had a significant increase in FIM scores at discharge, compared with those who started later. Furthermore, patients who started treatment within the first 15 days improved more and more quickly (and therefore had a shorter average stay) than those who started later.

The information available on the benefit of starting rehabilitation treatment immediately after a stroke is limited. In experimental animals, it has been observed that starting rehabilitation immediately after the occurrence of a stroke could have some harmful effects by increasing the infarcted cortical area[33]. However, in a phase II clinical study in patients with hemispheric stroke, Bernhardt et al.[34] showed that mobilisation in the first 24 hours not only had no negative effect, but the observed functional recovery was in fact better when compared to those with a more delayed mobilisation. A phase III clinical trial is currently underway that seeks to establish the potential efficacy of early post-stroke mobilisation. In light of the foregoing, starting rehabilitation treatment as early as possible[27,28,32] once the patient is medically stabilised is currently recommended.

Duration of the rehabilitation treatment

On another note, the recovery period and its degree have a relationship with initial stroke severity. The greater the initial severity of the stroke, the more functions there will be to recover, and so the process of neurorehabilitation will require more time. The Copenhagen Stroke Study (CSS)[35-37] analysed recovery patterns depending on the severity of stroke presentation, with an average follow-up of 6 months. Patients were stratified according to initial clinical severity (mild, 41% of patients; moderate, 26%; severe, 14%; and very severe, 19%) and their score on the Scandinavian Neurological Stroke Scale. It was noted that although in almost 95% of patients functional recovery was complete by the 13th week of evolution, this varied with initial stroke severity. The highest ADL score was achieved, on average, at around 2 months (8.5 weeks) in patients with mild stroke, at about 3 months (13 weeks) in patients with moderate stroke, at about 4 months (17 weeks) in patients with severe stroke and at about 5 months (20 weeks) in patients with very severe strokes. After 5-6 months of evolution, it was difficult to observe improvements in the scales that assess ADL.

In patients with stroke and initial condition between moderate and severe, Pinedo et al.[38] and Sánchez et al.[39] also found results similar to those reported by the CSS. The implementation of a multidisciplinary rehabilitation treatment in the acute and subacute phase enables 60-75% of these patients to regain their walking independence, and almost 50% to achieve functional independence in ADL.

The results available so far indicate that functional recovery after stroke and, therefore, brain plasticity processes are optimised if rehabilitation programs are initiated early and maintained for at least 6 months in the more severe strokes.

Intensity of rehabilitation treatment

In the process of rehabilitation, it is essential to establish the daily time for which patients should receive treatment to obtain the maximum benefit. As highlighted in the CERISE study[40], the intensity of the rehabilitation treatment performed varies greatly across countries; the average daily treatment lasts 60 min in the United Kingdom, 140 min in Germany and 166 min in Switzerland. Langhorne et al.[41] conducted a systematic review of 7 randomised trials to analyse the effect of different intensities of physiotherapy. Patients receiving more intensive physiotherapy improved in ADL and in degree of disability with respect to those who received less intensive treatment. Kwakkel et al.[42] conducted a meta-analysis to assess the potential beneficial effect on ADL, gait and dexterity of increasing the intensity of rehabilitation treatment in stroke patients. The group of patients who received intensive treatment (16 h more) improved significantly in the activities of daily living and in walking speed. In a randomised trial of patients with moderate stroke who began rehabilitation treatment approximately 2 weeks after symptoms appeared, Kalra et al.[43] found that more intensive treatment was associated with improved functional outcome and shorter hospital stay. More recently, these researchers[20] found, in a comparative study of rehabilitation strategies, that the average stay in the specific units for stroke rehabilitation was of 18.6 days in the United States versus 38 days in Canada. However, despite the fact that patients in the United States were being treated for fewer days at the units, they had a higher average FIM daily gain than those in Canada (1.4 units/day versus 0.6 units/day) and the percentage of institutionalised patients was also smaller (22 compared with 32.7%). These differences were attributed to the fact that, in the United States, admission to specific units for stroke rehabilitation is carried out earlier, treatment is more intense (sometimes even on weekends) and specific, and outpatient rehabilitation units are better structured and have less delay in attention.

Still, the benefits derived from the intensity of treatment are not limited to the aspects of physical and occupational therapy; they are also associated with a better prognosis for language disorders. In a review of 10 randomised studies, Bhogal et al.[44] noted that studies in which speech therapy or language deficit treatment obtained favourable outcomes were those in which therapies had been administered for an average of 8.8 h/week, for 11.2 weeks. In contrast, studies in which treatment had been given for an average of 2 h/week, for 22.9 weeks, showed negative results.

Given that intensive treatment is associated with better outcomes, the possibility of maintaining rehabilitation even during weekends could be raised. In this sense, Sonoda et al.[45] showed that rehabilitation treatment that continued during weekends was associated with shorter hospital stays and higher FIM scale scores at discharge, compared with the administration of treatment only on work days.

Despite the benefits derived from more intensive treatment, it is estimated that patients admitted into stroke units employ only 20% of their time in active therapies[46]; 53% of the time they remain in bed, 28% of the time sitting on a couch and for 60% of their time, patients are alone[47].

Specific rehabilitation units

Neurorehabilitation during hospitalisation

A patient who has suffered a stroke should be admitted to a neurology department as early as possible, with a stroke unit or team. Following admission, the neurorehabilitation or rehabilitation specialist from the multidisciplinary team of the unit should examine the patient and develop an individual plan that enables diagnosis of the disability/deficit, initiates appropriate rehabilitative treatment and anticipates the need for future resources. Once the patient leaves the stroke unit, neurorehabilitation should be maintained for the duration of hospital stay, following the rehabilitation plan and, if possible, at a specific stroke rehabilitation unit.

In recent years, given the importance of the rehabilitation process in the functional improvement of the patient, various special units for stroke neurorehabilitation have been created. These units have a number of distinctive features, such as being composed of a coordinated multidisciplinary team, having staff with specific interest in stroke, caretakers being involved in the neurorehabilitation process and having continued training programs[16,48]. Both the patient and family should be involved in the rehabilitation process, requiring appropriate training and information to enable them to continue care at home. The multidisciplinary team that forms specific neurorehabilitation units for stroke patients should include physicians dedicated to neurorehabilitation, physiotherapists, occupational therapists, speech therapists, orthotists, neuropsychologists and social workers, among other specialists. A neurologist with an interest in stroke treatment should be integrated within the multidisciplinary team of these units and actively contribute to improving neurorehabilitation treatment strategies[16].

Several studies have evaluated treatment efficacy at specific neurorehabilitation units for stroke patients. A systematic review of the Stroke Unit Trialists' Collaboration, in 2007[49], compared the rehabilitation received at specific rehabilitation units for stroke patients with that carried out at conventional rehabilitation units. After 1 year of monitoring, it was demonstrated that treatment at specific stroke neurorehabilitation units entailed shorter hospital stay and a lower percentage of patients who died, became dependent or required institutionalisation. Specific neurorehabilitation units are not only effective but also cost-effective, contributing to better economic resources management[50] and having a cost equal to or less than other alternative systems[20].

Notwithstanding the foregoing, specific rehabilitation units for stroke patients in Spain are scarce, neurologists are usually not actively involved in rehabilitation treatment, and rehabilitation is frequently not intensive or instituted early. Although the average hospital stay of patients with stroke in our country is similar to that of other European countries, the resources devoted to rehabilitation and use of technical aids or home adaptations are fewer[51]. Recently, in a broad study evaluating the implementation of quality standards in acute stroke care, Abilleira et al.[52] showed that "early mobilisation" and "assessment of rehabilitation needs" were hardly taken into account.

Outpatient neurorehabilitation

Since rehabilitation must be understood as a process, patients who have suffered a stroke should continue treatment at the end of their hospital stay. From a functional standpoint, outpatient rehabilitation treatment offers the opportunity to strengthen or increase the functional recovery acquired during hospitalisation. It also prevents the risk of further deterioration and enables some patients to avoid prolonged admission by being discharged sooner[53-55]. Outpatient treatment can take place at specific rehabilitation units or via home programmes. For the rehabilitation treatment to be maintained continuously after discharge, there must be coordination and collaboration between hospital and outpatient care, an organisation of stroke care with specific protocols and an availability of adequate resources for the real needs. The cost of treatment at outpatient rehabilitation units or home occupational therapy is significantly lower than at the hospital units. It is estimated that the cost of treatment as an outpatient for 3 months is equivalent to 4 days of admission[20]. Health systems with outpatient rehabilitation units and appropriate home care systems will have the ability to administer a more intensive and prolonged treatment at a similar cost, because they reduce hospitalisation-derived costs.

In 2005, The Early Supported Discharge Trialists[56] conducted a meta-analysis that included 11 randomised controlled trials comparing the strategy of "early discharge and outpatient rehabilitation" versus "conventional rehabilitative treatment" with hospital admission. It was found that the strategy associated with early discharge and outpatient rehabilitation reduced hospital stay; in addition,

it increased the percentage of long-term independent patients, reduced the percentage of institutionalised patients and was associated with an improvement in the scales that measured ADL and patient satisfaction.

Neurorehabilitation in stroke strategy in the National Health System

The recently published *Stroke Strategy of the National Health System*[57] establishes and develops a series of strategic lines; each of them raises a series of general and specific objectives and recommendations. Two of the strategic guidelines specifically refer to stroke rehabilitation.

In the strategic line on the "Care in acute phase for stroke patients" (point 2.2), the overall objective focuses on "reducing mortality at one month and increasing the autonomy of the survivors". To this end and among other specific objectives, it is necessary for the basic zones to have a stroke unit or team and for referral hospitals to have an established stroke code. Every hospital that attends stroke patients also needs to include a "Process of early rehabilitation with assessment of deficits and disabilities and initiation of treatment ".

The strategic line called "Rehabilitation and reintegration" (point 2.3) states the general objective of "Increasing the percentage of stroke patients who are fully integrated back into their personal and social life ".

Rehabilitation plays a crucial role in improving functional outcome and reducing disability. The Helsingborg declaration[58] sets as an objective that 70% of stroke survivors should be independent at 3 months. To this end, the *Stroke Strategy of the National Health System* raises a number of objectives, among which we must highlight:

—From the beginning of the process, all stroke patients will have an individual early rehabilitation plan that enables diagnosis of the degree of disability/deficit, as well as appropriate rehabilitation treatment and also makes provisions for future resources. In addition, stroke patients, on discharge from the rehabilitation plan, will receive a functional assessment to support their integration into their social and/or work environment.

Accordingly, the stroke strategy makes a series of recommendations of great interest, and emphasises the need to:

—Define the levels of rehabilitation care (acute, subacute and chronic) and care settings (hospital, medium-stay units, outpatient, home, etc.) so they can be coordinated correctly.
—These centres should have a multidisciplinary team that ensures the best possible recovery, and including occupational therapy and speech therapy is highly recommended. In addition, early intervention with regard to rehabilitation of cognitive and relational processes is recommended.

Conclusions

Neurorehabilitation is a subspecialty in which neurologists can be trained so they can actively participate in multidisciplinary teams that make up specific stroke neurorehabilitation units. Early initiation of neurorehabilitation at specific units, appropriate treatment duration and correct intensity lead to greater functional recovery and lower mortality, institutionalisation rate and hospital stay. Therefore, a planning effort is imperative so that patients who have suffered a stroke, in addition to receiving the best acute phase care, can also benefit from a specific neurorehabilitation therapy that is started early and is maintained with the necessary intensity and continuity during their hospital stay and subsequently on an outpatient basis after discharge.

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Conflict of interests

The authors declare no conflict of interests.

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