International
Journal of Neurorehabilitation

Cavalli et al., Int J Neurorehabilitation Eng 2017, 4:5
DOI: 10.4172/2376-0281.1000293

Rapid Communication Open Access

Stroke Rehabilitation: Which is the Main Functional Outcome to Reach?

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Abstract

Background: Stroke rehabilitation targets range from treatment of spasticity to pain reduction, gait speed gain, or autonomy amelioration. A correct evaluation of individual residual capabilities is essential to select the most appropriate rehabilitative programme; furthermore the observation of rehabilitative outcomes can provide information about gait training effects and possible compensation mechanisms.

Aim: To investigate the main outcome to reach in stroke rehabilitation.

Methods: We examined retrospectively a heterogeneous sample of 119 subjects recovered for the treatment of stroke outcomes. Functional parameters were assessed before and after rehabilitative treatment, such as upper limbs motility impairment, lower limb sensitiveness, muscle trophism or tone, necessity of auxilium, Berg and Fugl-Meyer scale.

Results: A consistent improvement of standing equilibrium was reported, regardless of gender, stroke nature, hemiparetic side, type of rehabilitation performed, botulin toxin use and initial conditions, with an average increase of Berg and Fugl-Meyer scales score of 14% and 21%, respectively. The variation of equilibrium and motility across treatment resulted directly proportional and negatively correlated to lower limbs sensitivity impairment. On the contrary, initial equilibrium resulted inversely correlated with the variation of motility and vice versa. Interestingly, older subjects seem to better increase equilibrium and sensitivity as measured by Fugl-Meyer scale.

Conclusion: In stroke subjects any type of rehabilitation leads to a consistent improvement of standing balance. While proportional to motility and sensitivity increase, this result is inversely correlated to initial motility score, suggesting that an appropriate evaluation of the stroke patient's functional parameters at admission contributes to select the main rehabilitation targets and the best therapeutic strategy.

Keywords: Stroke; Rehabilitation; Equilibrium; Motility; Age; Ischemic stroke

Introduction

Stroke is the major cause of disability worldwide, with an important social-economic impact [1]. One stroke on four is fatal and between 25 to 50% of the survivors requires a rehabilitative treatment [2]. According to the Copenhagen Stroke Study, 14% of survivors walk with assistance, while 22% are unable to ambulate [3], resulting in impairment in daily living [4].

Stroke rehabilitation is complex, long lasting and expensive and its functional outcome is influenced not only by brain lesion site and extension, but also by medical, demographic and neuropsycologic factors [1]. Age, for example, was reported as inversely proportional to amount of recovery [5]; similarly, disability at admission, measurable as Barthel Index (BI), is a powerful predictor of functional final outcome [1], as well as comorbidity. A further variable showing a relevant relationship with later outcome is the onset-to-admission interval (OAI), as rehabilitation beginning within 60 days after the stroke onset has been recognized to obtain better results compared to delay one [1].

The functions most frequently compromised by stroke are muscle strength, power, balance and gait [6], often associated with spasticity [7-9]. Muscle hypostenia, reduction in range of motion, abnormal muscle tone and loss of sensory and motor coordination contribute to difficulties of postural control in stroke patients [10], thus increasing the risk of falls, with a relevant socio-economic burden [11].

Therefore, recovering trunk control and balance is one of the main targets of rehabilitation for patients with stroke.

Materials and Methods

A retrospective analysis of records related to post-acute phase stroked patients was reported. Once excluded patients with disorders of consciousness, or with consistent comorbidity influencing the final outcome, such as severe respiratory or cardiovascular insufficiency, recent femoral fracture, general debility associated mental illness, or severe anemia, a total of 119 subjects admitted in Neuro-Rehabilitation Unit of Cisanello Hospital in Pisa, Italy, between 2009 and 2013 were included. Clinical characteristics detected by the physiatrist at the entrance in hospital were reported as distinct discrete parameters, including hemiparetic side, functional impairment of the affected upper limb, spasticity and hypotrophy of the lower limb, compromised tactile and proprioceptive sensitivity of lower limbs. The gait ability before rehabilitation was indicated with a score rising from 0 to 7 on the basis of the necessity of increasingly important walking aids. For each patient, the rehabilitative program was indicated, both for upper limbs (conventional physiotherapy, isokinetic dynamometer or no treatment) and for lower limbs (Lokomat, tapis roulant and conventional physiotherapy), as well as botulin toxin employment for the treatment of spasticity. The rehabilitative project outcome was reported as a clinical improvement in the control of the trunk, in the standing posture and in the gait pattern.

Moreover, standing balance was evalued by Berg scale, while Fugl-Meyer (FM) scale was performed to assess motility, equilibrium, sensitivity, articolarity and pain, before and after the treatment (Table 1). Of the whole sample, only thirty subjects performed gait tests and data about six min walking (6MWT), ten-meters (10MWT), time to get

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Received October 18, 2017; **Accepted** October 26, 2017; **Published** October 31, 2017

Citation: Cavalli L, Guazzini A, Rossi B, Chisari C (2017) Stroke Rehabilitation: Which is the Main Functional Outcome to Reach? Int J Neurorehabilitation 4: 293. doi: 10.4172/2376-0281.1000293

correlation analysis was carried out in order to investigate relations among clinical and quantitative parameters; then, a Monte Carlo Bootstrap method was applied for each variable in order to extract subsamples of comparable size, followed by the execution of the t test or of the ANOVA test.

Results

The patients, 64 males (54%) and 55 females (46%), had an average age of 66.8 years (± 11.7), ranging from 36 to 87 years. Stroke resulted of ischemic origin in 73 subjects and hemorrhagic in 46 with hemiparesis regarding right body side in 53 subjects, left in 58 or bilateral in 8 patients. The mean stay duration in rehabilitation was 55 days (± 30.1), ranging from 10 to 90 days.

Functional conditions at the access in hospital, such as upper limb functional impairment, lower limb spasticity and muscle hypotrophy,

Functional scales and tests	T_0 average score (before rehab) ± SD	T_1 average score (after rehab) ± SD	Average single patient T_0-T_1 variation (± SD)	Average percent single patient T_0-T_1 variation
Berg	29/56 ± 16.2	38/56 ± 13.6	7.94 (± 11.98)/56	+14%
FM mobility	36/98 ± 24.8	50/98 ± 30.0	14.4 (± 19.2)	+14.7%
FM equilibrium	6/24 ± 3.9	18/24 ± 2.8	2.5 (± 22.8)	+20.8%
FM sensitivity	15/24 ± 7.6	19/24 ± 5.6	3.4 (± 5.8)	+14.1%
FM articolarity	38/44 ± 6.5	40/44 ± 5.2	1.6 (± 4.0)	+3.6%
FM pain	38/44 ± 6.1	40/44 ± 5.1	1.51 (± 5.7)	+3.4%
10 m walking test_time (s)	54.8" ± 39.9	45.4" ± 35.0	-5.83" (± 23.7)	-17.5%
10 m walking test_speed (m/s)	0.29 m/sec ± 0.23	0.36 m/sec ± 0.24	0.05 (± 0.17)	+24.3%
6 min walking test distance (m)	102.8 mt ± 79.9	132.7 mt ± 88.8	18.98 (± 51.03)	+29.1
TUG (s)	55.7" ± 35.6	47.5" ± 34.7	-3.47" (± 11.98)	-14.7%

FM: Fugl-Meyer; TUG: Test Up and Go

Table 1: Clinimetric evaluation assessed before and after rehabilitation by means of Berg scale, Fugl-Meyer scale (F-M), 10 m walking test, 6 min walking test and test-up-and-go (TUG).

2A: Significant Pearson correlations between age, hospitalization, auxilium and the other parameters.

	Age	Rehabilitation duration (days)	Necessary auxilium at the entrance
Age	1		0.406 *
Auxilium required at the entrance	0.406 *		
Berg T_0	-0.288 **		-0.657 *
Berg T_1			-0.438 *
FM motility T_0		-0.255 **	-0.290 **
FM motility T_1		-0.316 *	
FM equilibrium T_0	-0.426 *		-0.629 *
FM equilibrium T_1	-0.378 *		-0.455 *
FM sensitivity T_0	-0.226 **		-0.282 **
FM pain T_0			- .244 **
10-MWT T_0	0.440 **		0.532 **
Speed T_0			-0.764 *
Speed T_1	-0.494 **		
6-MWT T_0			-0.739 *
TUG T_0	0.609 **		0.404 **

*: p value<0.001; **: p value<0.05

2B: Correlations between FM scores and other parameters.

	Delta FM motility	Delta FM equilibrium	Delta FM sensitivity	Delta FM articolarity
Age		0.194 **	0.215 **	
Auxilium required	0.276 **	0.399 *		
Berg T_0	-0.409 **	-0.319 **		
FM motility T_0		-0.292 **		
FM motility T_1	0.569 *			
FM equilibrium T_0	-0.345 *	-0.676 *	-0.416 *	
FM sensitivity T_0	-0.266 **	-0.429 *	-0.679 *	
FM articolarity T_0				-0.604 *
FM articolarity T_1	0.305 **	0.235 **		
FM pain T_0				-0.326 *
FM pain T_1	0.213 **			
6-MWY T_1	0.515 **			
Delta FM motility	1	0.641 *	0.444 *	0.230 **
Delta FM equilibrium	0.641 *	1	0.646 *	
Delta FM sensitivity	0.444 *	0.646 *	1	

*: p value<0.001; **: p value<0.05

2C: Berg scores correlations.

	Berg T_0	Berg T_1	Delta Berg
Age	-0.288**		
Necessary auxilium	-0.657*	-0.438*	0.388 **
FM motility T_0	0.326**		
FM equilibrium T_0	0.615*	0.355**	-0.4 **
FM equilibrium T_1	0.580*	0.687*	
FM sensitivity T_0	0.325**		
FM sensitivity T_1		0.317 **	
FM pain T_0	0.322 **		
10-MWT T_0		-0.565 **	
10-MWT T_1		-0.570 **	
Speed T_0	0.788 *	0.587 **	
Speed T_1	0.652 *	0.769 *	
6-MWT T_0	0.743 *	0.591 **	
6-MWT T_1		0.704 *	
TUG T_0		-0.727*	
TUG T_1		-0.637*	
Delta FM motility	-0.409**		0.642*
Delta FM equilibrium	-0.319**		0.465*
Delta FM sensitivity			0.341**

Table 2: Statistically significant correlations between the functional parameters analyzed: A) Correlations between age, hospitalization, auxilium and the other parameters; B) Correlations between FM scores and other parameters; C) Berg scores correlations.

tactile and/or proprioceptive sensitivity compromised in lower limbs and deambulation ability, are summarized in Figures 1A and 1B, rehabilitation strategies in Figure 1C.

The results of FM scale, performed in 104 subjects and Berg scale, assessed in 50 patients, before and after rehabilitative treatment are reported in Table 1, as well as 6MWT, TUG, 10MWT performed in 30 subjects. Statistically significant Pearson correlations among variables ($p<0.05$) are reported in Table 2A.

Equilibrium assessed by Berg and FM scales score results more impaired in oldest subjects, who require more important auxilia for walking, as well as tactile and proprioceptive sensitivity of lower limbs, which correlates with need of auxilia.

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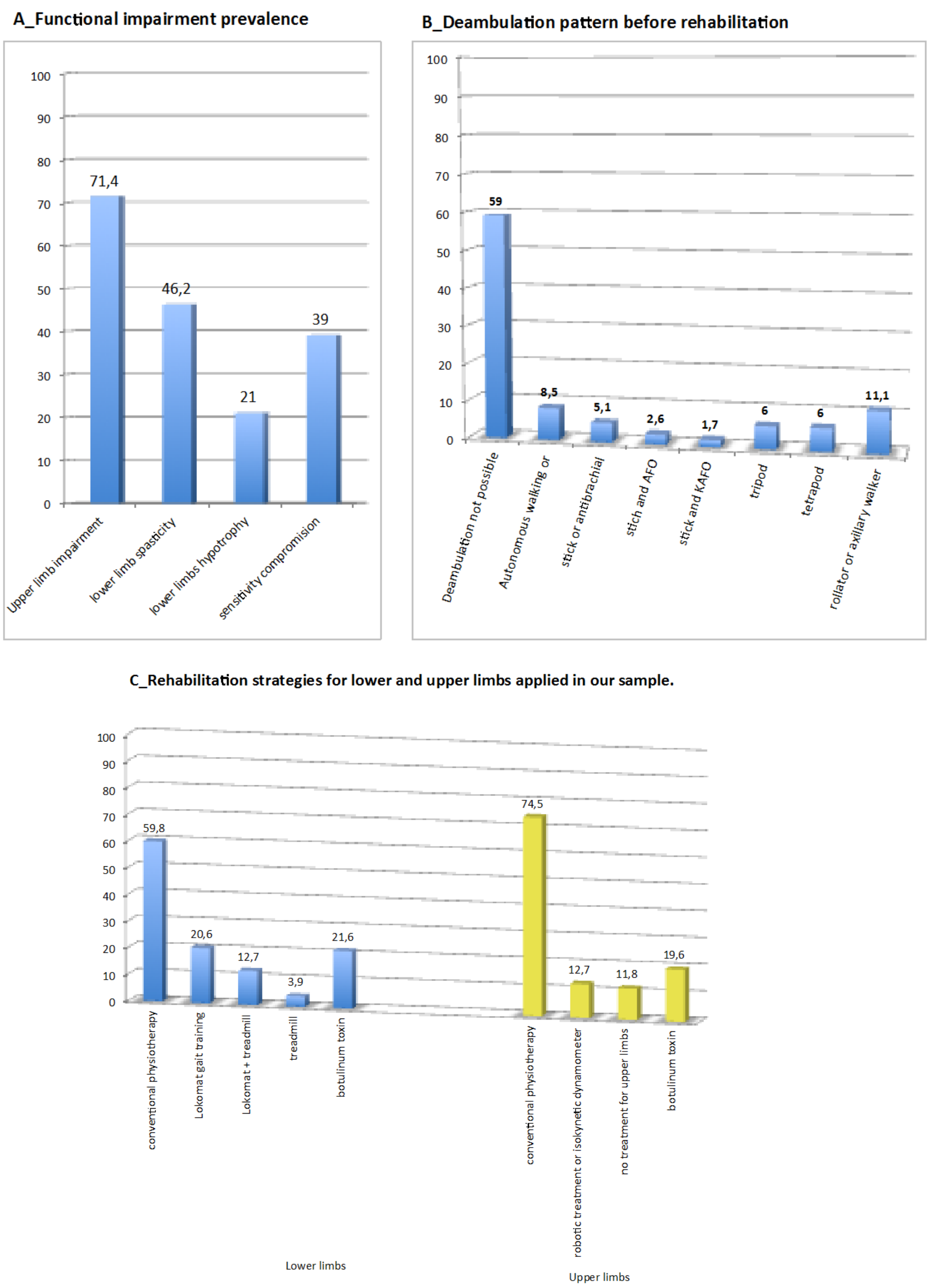

Figure 1: Functional baseline parameters and rehabilitation strategies.

Gait test reveals a significant influence of age, with older subjects employing longer time to walk for ten meters and to get up and go and with a lower speed at the end of treatment. Auxilia necessity results proportional to gait test impairment.

Further correlations have been evalued, between each parameter examined and the average "deltas", i.e., the single-patients variations of FM, Berg scale, gait test during rehabilitation treatment, as well as correlations between the deltas, each to the other (Table 2B).

Interestingly, older subjects seem to better increase equilibrium and sensitivity, while decreasing speed at gait test.

A positive correlation exists between the initial gait impairment, valued on the basis of the auxilium used and the improvement in motility and equilibrium at FM scale.

Initial equilibrium results inversely correlated with the variation of motility across treatment, as well as initial motility score is inversely proportional to equilibrium delta.

Sensitivity impairment at lower limbs is associated with lower motility and equilibrium variation. These latter parameters appear to be reciprocally proportional to final articolarity and the increase of articolarity across treatment is closely related to initial pain and vice versa.

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Regarding gait test, final performance at 6MWT positively correlates to motility variation, proportional to equilibrium, sensitivity, articolarity deltas and to the amelioration in the other gait tests. The progress in speed across treatment correlates to the amelioration in 6MWT, as well as happens for TUG and 10MWT.

Interestingly, variation of Berg score is positively correlated to variation of motility and sensitivity. When related to gait test, final Berg score correlates to T_0 and T_1 speed and 6MWT, but it is inversely proportional to T_0 and T_1 TUG and 10MWT, as shown in Table 2C.

Discussion

Neurorehabilitation is a method for relearning a task by compensatory strategies or by adaptively recruiting alternative pathway [12].

Post-acute one is the phase during which most of functional recovery can be obtained, where several prognostic factors may influence the global outcome. Advanced age often represents a unfavorable factor as potentially associated with comorbidity and fragility [2]; the presence of apraxia, aphasia or dysarthria, dysphagia and malnutrition, neglect, depression or anxiety represents a further obstacle to recovery [2]; the neurological lesion severity is a determinant predictor of patient's impairment, as well as timeliness, intensity and duration of rehabilitation have been shown to have a significant impact on ADL potential recovery [13].

Although there is no generally accepted method for rehabilitating stroke survivors, several studies support the choice of task-oriented training [13], where the recovery of movement, organized around a goal and constrained by the environment, is allowed not only by restoration from impairments but also by experience-dependent reorganization patterns in both the damaged and the contralateral hemisphere [13].

In this paper, the clinical and functional evaluation of a heterogeneous sample of 119 subjects hospitalized for stroke rehabilitation was examined, in order to figure out which weight was represented by each parameter in determining the final outcome.

Walking ability was considered as one of the main functional index, as influenced by balance, joint articolarity, muscle tone and strength, coordination. Therefore, deambulation at the entrance and at the end of the treatment was quantified in a 0 to 7 score scale, as the need of an increasingly assistant auxilium, from the absence of device or the only use of an ankle-foot-orthosis (AFO) represented by a 0 score, to the need of an antibrachial (score=1), or a stick with an AFO (2), or with a Knee-AFO (3), to the use of a tripod (4), a tetrapod (5), a rollator (6), or the inability to walk (7).

A Pearson correlation was established between gait impairment and all the other parameters examined, i.e. patient's sex and age, stroke type, lesion side, rehabilitative treatment duration, upper limb motility reduction, lower limb sensitiveness alteration, muscle hypotrophy or hypertonia, Berg and FM scale.

The tactile sensorial impairment at lower limbs, regarding 65.5% of the whole sample, resulting from the neurological examination and by FM scale, was more frequent in patients with hemorragic stroke and left hemiparesis and its recovery resulting by FM scale (delta FM sensitivity) was shown to correlate with a balance improvement (delta Berg), as reported in Table 2.

According to literature, old age resulted correlated to a worst gait ability score, as well as a low balance score measured by Berg and FM scales, both before (T_0) and after treatment (T_1). The resting parameters did not affect walking performance in a significant manner.

In our sample, undergone a retrospective study, the rehabilitation protocol was selected on the basis of individual needs and clinical characteristics, so that a comparison among different therapeutic approaches was not possible.

What emerged as consistent across all the patients was that the main gait impairment index is represented by initial balance (expressed by Berg and/or FM equilibrium score), which is inversely correlated with initial motility and vice versa ($p<0.05$, Table 2B). Interestingly, the balance improvement (delta FM equilibrium) appears as directly proportional to motility increase (delta FM motility) and vice versa ($p<0.05$, Table 2B).

Conclusion

The most appropriate strategy should be selected, as early as possible, on the basis of the functional parameters that each subject presents at the entrance in hospital, in order to reach the best motor performances allowing the major quality recovery of daily life. Our data suggest that balance recovery could be considered the main target of stroke rehabilitation.

Conflict of Interest

The authors declare that they have no competing interests. We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated.

Author's Contribution

Loredana Cavalli collected data in a database and drafted the main text. Andrea Guazzini made the statistical analysis. Bruno Rossi critically reviewed the whole paper adding his contribute. Carmelo Chisari planned the project and coordinated the work. All the authors reviewed and approved the final paper.

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