REVIEW ARTICLE

Occurrence and Predictors of Spasticity after First-ever Stroke: A Systematic Review

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Abstract

Aim and objective: To review recent studies on occurrence and predictors of post-stroke spasticity (PSS) after first-ever stroke.

Materials and methods: A systematic search of online databases including PubMed, Elsevier, and Springer was performed for literature describing occurrences and predictors of PSS. These data were collected and analyzed.

Results: Nine studies on prevalence including approximately 7,756 participants and 6 studies on predictors of PSS with approximately 755 patients were analyzed. The prevalence of PSS was 7–42% in a maximum 18-month post-stroke follow-up and increased muscle tone, greater severity of paresis, sensory impairment, and low Barthel Index score were predictors of PSS.

Conclusion: Under 65 years of age, patients are more prone to developing PSS, mainly in upper limbs at one year. For the determination of PSS prevalence, multiple parameters of spasticity measurement with biomechanical factors are to be needed. Early advanced rehabilitation, with background knowledge of predictors of PSS, the functional ability can be improved to achieve better outcomes and quality of life.

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Introduction

Worldwide stroke is the major burden leading to adult disability and mortality.[1] Morbidity after stroke is mainly due to spasticity which is a complex sensorimotor disorder defined as "impaired sensorimotor control from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of muscles".[2] Focused rehabilitation can alleviate spasticity which limits activity due to contractures and/or pain.[3,4] As a result, the cost of healthcare for stroke survivors with spasticity has been estimated as being four times higher than other secondary complications.[5]

The impact of spasticity on post-stroke recovery may not be obvious at the onset of ictus hence lacking its importance in the early phase. The upper extremity is more prone to develop post-stroke spasticity (PSS) than lower limbs.[6]

The frequency of spasticity in the upper limb varies from 7 to 38%[7–10] in the first 12 months, and was found to be 46% in patients with initial impaired arm function.[11] To intervene in the earlier management of PSS and yield better outcomes, it is essential to recognize and identify the predictors of spasticity to help rehabilitation professionals.[12]

The aim of this systematic review is therefore to investigate the occurrence of spasticity after motor stroke and to identify clinical predictors of subsequent spasticity. It would be helpful to know which factors can identify patients who are at high risk of developing severe PSS, especially during the initial admission.

Materials and Methods

Search Strategy

Up to May 2020, all eligible and relevant articles regarding prevalence and predictors of PSS were analyzed. The major online databases including PubMed, Elsevier, and Springer were searched with the limitation to publications written in English. The terms used to search were natural history, clinical course, prevalence and predictors, stroke, and spasticity. Cross-references were also searched for all initially included articles. Preferred reporting items for systematic reviews guidelines were strictly followed by the authors.

Eligibility Assessment

All studies that reported relevant and extractable data were included after independent assessment. Exclusion criteria were (1) case reports and case series, letters to the editor, and conference abstracts (2) studies that reported incomplete or non-extractable data (3) non-human studies. Traumatic Intracerebral hemorrhage, subarachnoid hemorrhage, cortical venous thrombosis, and recurrent stroke were also excluded. Demographic data including sample size, study type, geographic location, and prevalence were extracted. During the study selection process if any discrepancy was found then a reasonable consensus between all the reviewers was made.

Results

From the thorough search process, a total of 15 papers (9 of prevalence and 6 of predictors) were eligible for qualitative analysis. Total 7,756 participants were included in estimating post-stroke prevalence in which prevalence of PSS was found in the range of 7–42% (at onset, 3-month, 6-month, 12-month, and 18-month follow-up—21, 7–19, 42.6, 18–38, and 20% consecutively) which

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summarized in Table 1. For evaluating predictors of PSS, total 755 patients were included in which development of increased muscle tone, greater severity of paresis, sensory impairment, and low Barthel Index score were predictors of PSS. These characteristics are summarized in Table 2.

Discussion

Work-again and walk-again burden in recovering patients after stroke is mainly related to PSS; hence, in this article, we want to discuss the occurrence of PSS and its relation to various factors like age, duration of symptom onset, early intervention of advanced rehabilitation, and site of weakness.

Description of spasticity and its clinical implications are still having lack of attention. The prevalence of PSS in initial studies was approximately 60%;[13] however, current studies show lower rates of spasticity in 7–42% of post-stroke patients.

Three follow-up studies of a Swedish cohort[7,14,15] report a frequency of 18–21% in patients examined at stroke onset, 3, 12, and 18 months after stroke, while two studies from the United Kingdom[16,17] report a frequency of 36–38% in patients at 1-year post-stroke. According to follow-up time period and geographical distribution showed a higher frequency of PSS in the United Kingdom population at 1 year than the Swedish cohort. One Brazilian study reported a prevalence of spasticity at the level of 25%, as assessment is done year after stroke. Among the hemiparetic patients, 26–36% exhibited spasticity. These findings are in accordance with those of O'Dwyer et al., who found electromyographically verified spasticity in 21% of hemiparetic patients assessed 13 months after stroke.[18]

The discrepancies between the UK, Swedish, and Brazilian studies might be related to a few important variables. Primarily, the TAS as the outcome measure was used in the two UK studies[16,17] for assessing muscle tone (wrist, elbow, hip, knee, ankle), while the MAS was only used at the elbow. The Swedish and Brazilian cohorts were examined using the MAS as a primary spasticity measure.

The use of different methods of assessment might be the main source of the difference in spasticity prevalence between the studies. It may also be the reason for the discrepancy between

Table 1: Prevalence of spasticity and characteristics of the population

Study	*Numbers of patients*	*Etiology of stroke*	*Muscle tone assessment methods*	*Time from ictus to evaluation*	*Prevalence of spasticity*
Watkins et al., 2002	106	Stroke (TIA and SAH excluded)	TAS, MAS	12 months	38%
Leathley et al., 2004	106	Stroke (TIA and SAH excluded)	TAS	12 months	36% 21% (severe spasticity)
Sommerfeld et al., 2004	95	First-ever stroke (SAH and cerebellar lesions excluded)	MAS	At onset (mean, 5.4 days) and 3 months	21% (initially) 19% (at 3 months)
Welmer et al., 2006	66	First-ever stroke (SAH and cerebellar lesions excluded)	MAS	18 months	20%
Lundström et al., 2008	140	First-ever stroke (cerebral infarction or intracerebral hemorrhage excluded)	MAS	12 months	18% 6% (disabling spasticity)
Moura et al., 2009	146	Ischemic stroke	MAS	12 months	25%
Urban (2010)	301	First-ever ischemic stroke	MAS	6 months	42.6%
Eyngyeomcha et al. (2016) Kosco study	6,675	First-ever stroke	MAS	3 months	7.3%
Michał J. Schinwelskie et al. (2019)	121	First-ever stroke	MAS	12 months	35%

TAS, tone assessment scale; MAS, modified ashworth scale; TIA, transient ischemic attack; SAH, subarachnoid hemorrhage

Table 2: Predictors of post-stroke spasticity

Study	*Number*	*Time after stroke*	*Evaluation method*	*Predictors of spasticity*
Wissel et al. (2010)	94	Up to 4 months	Modified Ashworth Scale (spasticity: MAS >0)	Moderate increase in muscle tone at baseline and/or first follow-up (MAS = 2), Low Barthel Index at baseline, hemispasticity, involvement of more than two joints at first follow-up, and paresis at any assessment point
Urban et al. (2010)	211	Up to 6 months	Modified Ashworth Scale (spasticity: MAS >0)	More severe paresis in the proximal and distal limb muscles had a higher risk for developing spasticity
Lundstrom et al. (2010)	49	Up to 6 months	Modified Ashworth Scale (spasticity: MAS >1)	Any paresis in affected limb more in upper limb than lower limb
Kong et al. (2011)	163	Up to 3 months	Modified Ashworth Scale (spasticity: MAS >1)	Upper limb weakness
Opheim et al. (2014)	117	Up to 12 months	MAS	Reduced sensorimotor function. Reduced sensation
Michał J. Schinwelski et al. (2019)	121	Up to 12 months	MAS	Severe disability and muscle weakness

the studies that assessed the prevalence of severe spasticity called disabling spasticity (DS).

The MAS is the most commonly used scale to assess tone in clinical practice as well as in research studies.[19] Recognized limitations of the scale include—it measures only one feature of spasticity, i.e., resistance to passive movement. It does not differentiate the effects of reflex hyperexcitability from those of biomechanical factors. This may explain why not all of the spastic patients had hyperreflexia and only one-third of the spastic patients experienced muscle stiffness.[14] National healthcare systems may also influence the final results. Easy access to rehabilitation following the acute phase of a stroke may result in a lower rate of spasticity, mainly severe or DS.

Spasticity was more frequent in younger patients (under 65 years) at 12 months,[7] at the onset of stroke (mean, 5.4 days), and 3 months after stroke. This observation is difficult to explain. Aging is related to the decrease in reflexes, as seen in the tendon reflexes and the tonic reflexes.[20] This might be a possible explanation for the differences between younger and older patients found in the presented studies. This might be influenced by an underestimation in the oldest age group (>85 years) because of the loss of those with more severe conditions.

Spasticity was more common in the upper extremity than in the lower extremities.[7,14,15] The severity of upper extremity spasticity was associated with the severity of impaired upper extremity voluntary movements, but this was not the case for the lower extremities. These differences between the upper and lower extremities may be explained by differences in supraspinal control as the upper limb normally functions predominantly under voluntary control whilst movements of the lower limb are influenced to a larger extent by spinal locomotor centers.[21] Spasticity was the most common in muscles resisting gravity, i.e., the arm flexors and leg extensors, which is in accordance with a previous report.[22] After reviewing several studies, we were not able to find the relation of laterality for PSS.

Evidences regarding the onset and course of spasticity during the first-year PSS are not much. To reduce the PSS knowledge about predictors to develop spasticity is essential. Although the prediction of developing PSS is likely improved using measures of early rehabilitation, the time point at which these measures should be taken is unclear. So, we are aiming to review various predictors responsible for PSS and their timing of implication to prevent spasticity.

In the study of Lundstrom et al.[6] who included 49 subjects with any paresis after first-ever stroke and examined at baseline (day 2–10 after stroke), and follow-up of 1 and 6 months. Smoking and younger age were associated with increased risk and they also found paresis of limb mainly severe paresis of the arm at baseline to be associated with a higher risk for spasticity ($p < 0.001$) as early as 1 month after stroke.

In Urban et al.'s study of 211 patients with first-ever stroke and limb, paresis was included. They were examined in the acute phase after stroke (within 5 days) and 6 months later. A severe degree of paresis, hemihypoesthesia at stroke onset, and lower Barthel index at 6 months were more common in subjects with PSS ($p < 0.001$).[9] Similarly, sequential follow-up at 6 days, 6 weeks, and 16 weeks after stroke Wissel and coworkers reported that the presence of hemiparesis and low Barthel index were predictors of PSS in the study of 94 patients.[10]

Predictors for involvement of upper limb rather than lower limb were found to be more. This is endorsed by Kong et al. in their study of 163 patients of a first-ever ischemic stroke, in which as a predictor poor upper limb function was the most important factor for "moderate to severe spasticity" (MAS >2) ($p < 0.001$).[8] Another recent study included 117 patients of a first-time stroke in which upper-extremity paresis day 3 post-stroke was consecutively included.

Evaluations were made at admission and at 3 days, 10 days, 4 weeks, and 12 months post-stroke. They found that sensorimotor function was the most important predictor both for "any" and "severe spasticity" 12 months post-stroke.[23]

Michał J Schinwelskie et al.'s study on 121 patients also found muscle weakness as predictors of PSS; however, other studies did not emphasize muscle weakness and functional disability as a predictor for PSS.

Conclusion

Available evidence support that under 65 years patients are more prone to developing PSS, mainly in upper limbs at one year. However, no sufficient evidence of laterality, type, and etiology of stroke are available for PSS. Prevalence of PSS is in the range of 7–42% in recent studies. For actual determination of PSS prevalence, a new systematic scale is needed which includes multiple parameters of spasticity measurement with biomechanical factors.

Further investigations are necessary to validate the correlation of sensory-motor impairment, associated diseases, and surrogate markers from magnetic resonance imaging like lesion load and location. Early advanced functional, virtual and robotic rehabilitation, with background knowledge of predictors of PSS, functional ability can be improved to achieve better outcomes and quality of life. However, further research is warranted for occurrence and predictors of PSS with emerging techniques.

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