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ORIGINAL REPORT

SYMPTOMATIC UPPER LIMB SPASTICITY IN PATIENTS WITH CHRONIC STROKE ATTENDING A REHABILITATION CLINIC: FREQUENCY, CLINICAL CORRELATES AND PREDICTORS

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Objective: **To document the frequency, clinical correlates and predictors of symptomatic upper limb spasticity in patients one year or more after stroke.**
Design: **Cross-sectional study.**
Subjects: **A total of 140 patients after stroke attending a rehabilitation clinic.**
Methods: **Assessments of spasticity, upper limb function and self-care ability using the Ashworth Scale (AS), Motor Assessment Scale and Modified Barthel Index. We categorized spasticity as: spasticity in general (AS score ≥1), severe spasticity (AS score ≥3) and symptomatic spasticity (spasticity affecting upper limb function).**
Results: **The mean age (standard deviation, SD) was 61.0 (SD 13.3) years and patients were evaluated at 41.7 (SD 35.1) months after stroke onset. The observed frequency of spasticity in general, severe spasticity and symptomatic spasticity was 78.6%, 38.6% and 30%, respectively. The total AS score was the most important correlate of symptomatic spasticity; patients with higher scores were likely to be symptomatic ($p=0.001$). Severe spasticity was predicted by poor lower extremity power ($p=0.002$), high National Institute of Health Stroke Scale score ($p=0.015$) and presence of dysphasia ($p=0.046$) on admission to rehabilitation. No predictors of symptomatic spasticity could be established.**
Conclusion: **Symptomatic spasticity is relatively common in patients with chronic stroke and is significantly correlated with the severity of spasticity.**

Key words: upper extremity; muscle spasticity; stroke; rehabilitation.

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INTRODUCTION

Spasticity is a motor disorder characterized by velocity-dependent resistance to muscle stretch when the limb is flexed or extended in patients with upper motor neurone lesions (1). Although upper limb spasticity is often assumed to be common after a stroke, studies of its prevalence are limited. Sommerfeld etal. (2) evaluated 95 first-ever patients after stroke and reported upper limb spasticity in 17 patients (2). When these patients were evaluated at 18 months post-stroke, the frequency of upper limb spasticity was little-changed, at 19.1% (3). In 2 other studies by Lundström et al. (4) and Watkins et al. (5), upper limb spasticity was present in 17% and 40% of patients at one year post-stroke. It must be mentioned that in the study by Watkins et al., patients with recurrent stroke were also included.

Not all patients with upper limb spasticity will have symptoms, that is, experience spasticity-related problems. In those with symptoms, these can be categorized into: (*i*) those relating to passive function, e.g. hand hygiene, wearing of upper garment, application of splints; (*ii*) pain; (*iii*) associated reaction; and (*iv*) those relating to impaired active function. Although the impact of spasticity on patient functioning had been examined previously, these were predominantly focused on how spasticity affected self-care abilities and health-related quality of life (2–5). These showed weak or moderate associations between spasticity, activity performance and health-related quality of life. It must be highlighted that in these studies, both upper and lower limb spasticity were investigated together, and hence the impact of spasticity on patient functioning was also evaluated from upper and lower limb spasticity taken together. Lundström et al. studied "disabling spasticity" in stroke patients and found that only 4% of patients were deemed to have disabling spasticity, which was defined as spasticity needing therapeutic intervention (4). However, there were no details on the type of disabilities and therapeutic intervention needed.

This paucity of data on impact of post-stroke spasticity on upper limb functioning is in sharp contrast to the relative abundance of studies on treatment of upper limb spasticity. Understanding how spasticity affects upper limb functioning, its clinical correlates and determining which patients are likely to develop symptomatic spasticity is relevant, as patients who are symptomatic are the ones most likely to need treatment.

With the above in mind, we conducted a study of a cohort of patients attending a rehabilitation clinic who were more than one year post-stroke with the following aims: (*i*) to document frequency of symptomatic upper limb spasticity; (*ii*) to evaluate the areas of upper limb function affected by spasticity; and (*iii*) to assess clinical correlates and predictors of symptomatic upper limb spasticity.

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SUBJECTS AND METHODS

Subjects

This was a cross-sectional study of patients who had had a first-ever stroke one year or more previously. Patients were recruited consecutively from the outpatient clinics of our rehabilitation centre over a 9-month period. Our rehabilitation centre is the largest tertiary rehabilitation centre in the country, with 92 inpatient rehabilitation beds, half of which are dedicated to stroke patients. The diagnosis of stroke was confirmed on computed tomography (CT) and/or magnetic resonance imaging (MRI) brain scans in all patients.

The inclusion criteria were: (*i*) one year or more post-stroke onset; (*ii*) inpatient stroke rehabilitation completed at our centre previously; and (*iii*) presence of weakness of the affected upper limb. Exclusion criteria were: (*i*) recurrent stroke; (*ii*) bilateral weakness; and (*iii*) presence of orthopaedic or other neurological conditions affecting upper limb function.

Outcome measures

The following outcome measures were evaluated during the patient's outpatient visit:

- Spasticity of the shoulder adductors, elbow, wrist and finger flexors, using the Ashworth Scale (AS) (6). This was measured with the patient sitting comfortably. The AS is a 5-point ordinal scale with documented reliability (7). It scores from 0 to 4, with 0 indicating absence of spasticity and 4 indicating severe spasticity. Spasticity was further categorized into spasticity in general (AS score ≥1 in any joint) and severe spasticity (AS score ≥3 in any joint).
- Impact of spasticity on upper limb function in the following domains:
  - Passive function: including problems of hand hygiene, skin integrity, prevention of contracture, wearing of upper body garment, wearing of splints and cosmesis.
  - Active function: this refers to spasticity impairing the use of the upper limb for functional activities such as forward reach, grasp and release.
  - Pain: this refers to pain as a result of spasticity and excluded other causes of pain, e.g. central post-stroke pain, complex regional pain syndrome, etc.
  - Associated reaction: this refers to involuntary movements of the paretic upper limb (usually elbow flexion) that is elicited by a variety of stimuli including the use of the unaffected limbs and upright posture.

The impact of spasticity was evaluated through direct questioning and substantiated by detailed clinical examination. In patients with cognitive or language impairments who were not able to answer this question, answers from their caregivers were taken instead. Symptomatic spasticity was deemed to be present when problems related to any of the above domains were present.

- Function of the affected upper limb as measured on the upper limb items of the Motor Assessment Scale (MAS) (8). The MAS is based on a task-oriented approach to evaluation that assesses performance of functional tasks rather than isolated patterns of movement. The upper limb items of the MAS consist of the following: Shoulder Movements, Hand Movements and Advanced Hand Activities. Each item is assessed using a 7-point scale from 0 to 6. A score of 6 indicates optimal motor behaviour. Successfully completing a higher-level item suggests that the individual is able to perform the lower level items that correspond to lower scores, and thus these lower items can be skipped from the assessment. In this study, the scores of Shoulder Movements, Hand Movements and Advanced Hand Activities were summated to provide an overall score, Motor Assessment Scale-Total. The MAS has been validated for the assessment of upper limb function in stroke (9).
- Upper extremity motor power. The best motor power of the shoulder, elbow and fingers were measured and then summed to provide an Upper Extremity Motor Index (UEMI). This ranges from 0 to 15, with 15 indicating full motor power.
- Self-care function as assessed on the Modified Barthel Index (10).

All outcome measures were assessed by the first author.

The patient's medical record was also retrospectively reviewed for the following data on admission to rehabilitation: nature of stroke (ischaemic vs haemorrhagic), duration from stroke onset to admission to rehabilitation, scores on the Modified Barthel Index (MBI), National Institute of Health Stroke Scale (NIHSS) (11) and Upper and Lower Extremity Motor Index. The NIHSS is a 42-point ordinal scale that measures neurological deficit, including consciousness, hemianopia, sensation, neglect and language, and is frequently used in stroke studies. The Lower Extremity Motor Index (LEMI) is a summation of the best motor power of the hip, knee and ankle and, like the UEMI, scores from 0 to 15.

The study was approved by the institution's ethics review board.

Statistical analysis

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS version 16). All statistical tests were carried out at 5% level of significance. Two primary analyses were performed. The first examined factors associated with symptomatic spasticity. Symptomatic spasticity was dichotomized into present and absent. The covariates studied were: age, sex, total AS score (summation of AS scores of the shoulder, elbow, wrist and finger), UEMI, MBI and MAS – Total scores.

The second analysis examined predictors of upper limb spasticity. Three predictive models were evaluated. The first examined predictors of spasticity in general (AS score ≥1 in any joint), the second predictors of severe spasticity (AS score ≥3 in any joint) and the last, predictors of symptomatic spasticity. The following admission to rehabilitation data were evaluated for their predictive potential: age when stroke occurred, sex, nature of stroke, dysphasia, neglect, hemianopia and MBI, NIHSS, UEMI and LEMI scores. Dysphasia, neglect, hemianopia were diagnosed based on scores of items of the NIHSS, which evaluated for these impairments. They were classified into absent (score 0) or present (score ≤1).

Univariate analyses included Pearson correlation and *t*-test for continuous variables, and χ^2 test for categorical variables. Multivariate logistic regression was performed if there was more than one significant covariate in these analyses. No power analysis was performed for this study.

RESULTS

Demographics and stroke characteristics

A total of 165 patients were screened and 25 patients were excluded (12 patients had not previously received inpatient rehabilitation at our centre, 10 patients had a recurrent stroke, and 3 patients had other neurological/orthopaedic conditions affecting upper limb function). The baseline data of the study cohort are shown in Table I. Overall, the study cohort is relatively young, with a mean age of 61.1 (SD 13.3) years. Hypertension, diabetes and ischaemic heart disease were present in 126 (90.0%), 43 (30.7%), 136 (97.8%) and 26 (18.5%) of patients, respectively.

Data of interest on admission to rehabilitation

Admission data are shown in Table I. Patients were admitted to rehabilitation at approximately 2 weeks after stroke onset. The low mean UEMI and LEMI scores indicate that significant upper and lower limb weakness were common.

Prevalence and distribution of upper limb spasticity

Spasticity in general was present in 110 patients (78.6%), severe spasticity in 54 patients (38.5%) and symptomatic

Table I. *Baseline data (n = 140)*

Demographic and stroke characteristics: clinical variables	
Age, years, mean (SD)	61.0 (13.3)
Sex, male/female, *n*	88/52
Duration from stroke onset to assessment (months), mean (SD)	41.7 (35.1)
Nature of stroke, *n*	
Infarct/haemorrhage	102/38
Side of hemiplegia, *n*	
Left/right	71/69
Data of interest on admission to rehabilitation, mean (SD)	
Duration from stroke onset to admission to rehabilitation (days)	15.6 (13.6)
National Institute of Health Stroke Scale (rehabilitation)	10.8 (4.7)
Upper Extremity Motor Index (rehabilitation)	3.4 (3.9)
Lower Extremity Motor Index (rehabilitation)	4.9 (4.7)
Modified Barthel Index (rehabilitation)	42.8 (26.4)
Hemianopia, *n* (%)	55 (39.2)
Dysphasia, *n* (%)	37 (26.4)
Neglect, *n* (%)	32 (22.8)

SD: standard deviation.

Table II. *Results of outcome measures (n = 140 patients)*

Outcome measure	Results
Number of patients with spasticity, *n* (%)	110 (78.6)
Ashworth Scale score of 1 in any joint	19
Ashworth Scale score of 2 in any joint	37
Ashworth Scale score of 3 in any joint	52
Ashworth Scale score of 4 in any joint	2
Joints affected by spasticity, *n*	
Shoulder	77
Elbow	99
Wrist	105
Fingers	107
Ashworth Scale score of joints affected by spasticity, mean (SD)	
Shoulder	0.9 (0.7)
Elbow	1.6 (0.9)
Wrist	2.0 (0.9)
Fingers	2.1 (0.8)
Motor Assessment Scale – Total, mean (SD)	7.5 (5.9)
Upper Extremity Motor Index mean (SD)	7.9 (4.3)
Modified Barthel Index mean (SD)	87.0 (19.1)

SD: standard deviation.

spasticity in 42 patients (30%) (Table II). The wrist and fingers were most affected and the shoulder the least. A similar trend was also observed with regards to severity of spasticity of the joints.

Areas of upper limb function affected by spasticity

In the 42 patients with symptomatic spasticity, passive function was the domain affected most by spasticity (39 patients), followed by associated reaction (29 patients), pain (21 patients) and active function (6 patients). Thirty-six patients had problems affecting more than one domain.

Factors associated with symptomatic spasticity

The results of analysis of factors associated with symptomatic spasticity are shown in Table III. These showed that UEMI, MAS-Total and AS-Total scores were significantly correlated with symptomatic spasticity. Patients with symptomatic spasticity had worse upper limb power and function and more severe spasticity than those without symptoms. However, on multivariate logistic regression, only AS-Total score was significant ($p = 0.001$).

Predictors of upper limb spasticity

Predictors of spasticity in general (AS score ≥1). On univariate analysis, neglect and scores of UEMI, LEMI, NIHSS and MBI on rehabilitation admission were significant predictors (Table IV). Patients with spasticity were more likely to have neglect, higher NIHSS and lower UEMI, LEMI and MBI scores. On multivariate logistic regression, UEMI score was the most important predictor ($p = 0.008$) followed by LEMI score ($p = 0.08$).

Predictors of severe upper limb spasticity. On univariate analysis, dysphasia (rehabilitation), UEMI (rehabilitation), LEMI (rehabilitation) and NIHSS (rehabilitation) scores were significant predictors (see Table V). On multivariate logistic regression, dysphasia ($p = 0.046$), NIHSS ($p = 0.015$) and LEMI scores ($p = 0.002$) were still significant, with LEMI score being the most important predictor.

Predictors of symptomatic upper limb spasticity. None of the covariates were significant predictors of symptomatic upper limb spasticity.

Table III. *Analysis of covariates associated with symptomatic spasticity (n = 110 patients)*

Covariate	Symptomatic spasticity (yes/no)	*p*-value (yes/no)
Age, years, mean (SD)	58.7 (11.4)/60.4 (13.3)	0.25
Sex, *n*		
Male	26/43	0.88
Female	16/25	
Post-stroke duration, months, mean (SD)	39.4 (30.6)/45.1 (38.1)	0.42
Ashworth Scale, total, mean (SD)	8.5 (2.5)/5.9 (2.7)	<0.001
Upper Extremity Motor Index, mean (SD)	6.2 (3.1)/7.1 (4.1)	0.003
Motor Assessment, Scale-Total, mean (SD)	1.6 (2.7)/2.7 (3.1)	0.001
Modified Barthel Index, mean (SD)	87.4 (18.0)/84.2 (19.7)	0.47

SD: standard deviation.

Table IV. *Predictors of spasticity in general (Ashworth Scale score ≤1) (n = 140 patients)*

Admission to rehabilitation data	Spasticity (yes/no)	*p*-value
Age when stroke occurred, years, mean (SD)	62.4 (12.8)/58.8 (14.1)	0.19
Upper Extremity Motor Index, mean (SD)	2.0 (3.0)/7.1 (3.7)	<0.001
Lower Extremity Motor Index, mean (SD)	3.6 (4.4)/8.5 (3.0)	<0.001
Modified Barthel Index, mean (SD)	35.5 (24.7)/56.0 (28.4)	0.006
National Institute of Health Stroke Scale, mean (SD)	11.7 (4.4)/7.2 (3.9)	<0.001
Dysphasia, *n*	35/8	0.58
Neglect, *n*	37/4	0.022
Hemianopia, *n*	47/7	0.058

SD: standard deviation.

DISCUSSION

This is the one of the few studies evaluating symptomatic upper limb spasticity in patients after stroke, and its specific impact on upper limb function. In this cohort of 140 patients with chronic stroke attending a rehabilitation clinic, the frequency of symptomatic spasticity was 30%, while those of spasticity in general and severe spasticity were 78.6% and 38.6%, respectively. These rates of upper limb spasticity are much higher than those reported previously. For example, Lundström et al. (4) observed that only 17% of stroke patients at 1 year post-stroke had upper limb spasticity (defined as a Modified Ashworth Scale ≤1) and only 4% had "disabling" spasticity. Using the same definition, Welmer et al. (3) reported a spasticity rate of 17.9% in patients who were 18 months post-stroke.

Much of this disparity can be attributed to differences in case-mix and study settings. Previous hospital-based studies included patients with varying stroke severity, including those with mild weakness who were less likely to develop spasticity. Patients in our study, on the other hand, were pre-selected based on their need for inpatient rehabilitation. They were significantly younger, but were also more likely to have significant motor impairments and to be dependent functionally. This is borne out by the findings of a low mean UEMI score of 3.4 and MBI score of 42 on rehabilitation admission. Another reason for the high rate of spasticity is the bias introduced as a result of studying only patients who were still on follow-up at our centre, as these patients were more likely to need continued rehabilitation care, including management of spasticity. Finally, one can argue that as patients in our study were evaluated at a much longer period after stroke compared with previous studies, the risk of soft tissue changes or contractures is likely to be higher, especially if the affected muscles/joints were not stretched or ranged regularly. This could also have accounted for the increased rate of spasticity. This is because the MAS which was used to assess spasticity, measures resistance to imposed passive movement when the limb is briskly stretched through full range of available movement about a joint. As such, it does not differentiate whether the increased resistance is a result of reflex hyperexcitability, biomechanical changes of soft tissues, or both. However, in a small study of 24 patients who were examined 1–13 months after stroke, O'Dwyer et al. (12) observed that muscle contracture was already evident at 2 months after stroke and there was no correlation between muscle contracture and time since the stroke.

Among the 42 patients with symptomatic upper limb spasticity, problems related to passive function, associated reaction and pain were commonly reported, while those related to active function were infrequent. It is noteworthy that 85.7% of these patients had problems in more than one domain. The above findings are not surprising given the generally poor upper limb power and function present in the study cohort.

Although UEMI and Motor Assessment-Total scores were significantly correlated with symptomatic spasticity, only AS-Total score was significant on multivariate analysis, this being almost 3 points higher in the symptomatic spasticity group. This finding underlies the importance of spasticity severity in determining whether patients will develop symptoms. That the MBI score did not correlate with symptomatic spasticity can be explained by the fact that many of the self-care items on the MBI can be performed through compensatory techniques involving the good upper limb.

Identifying patients who are likely to develop severe and/or symptomatic spasticity is relevant as they are the ones most likely to benefit from treatment. In a previous study, lower day 7 Bar-

Table V. *Predictors of severe spasticity (AS score of 3–4) (n = 140 patients)*

Admission to rehabilitation data	Severe spasticity (yes/no)	*p*-value
Age, years, mean (SD)	60.4 (11.2)/62.2 (14.1)	0.41
Upper Extremity Motor Index, mean (SD)	1.3 (2.4)/4.0 (4.1)	<0.001
Lower Extremity Motor Index, mean (SD)	2.2 (3.0)/5.8 (4.3)	<0.001
Modified Barthel Index, mean (SD)	40.4 (24.1)/44.3 (27.4)	0.42
National Institute of Health Stroke Scale, mean (SD)	12.2 (4.0)/10.0 (4.9)	0.01
Dysphasia, *n*	21/28	0.024
Neglect, *n*	14/35	0.89
Hemianopia, *n*	20/28	0.62

SD: standard deviation.

thel Index score and early arm or leg weakness were significant predictors of spasticity, whereas lower day 7 Barthel Index score, left-sided weakness and, interestingly, history of smoking were significant predictors of severe spasticity at 12 months post-stroke (13). In our study, lower UEMI score was the most important predictor of spasticity in general. On the other hand, the most important predictor of severe spasticity was lower LEMI score followed by higher NIHSS score and presence of dysphasia. As these 3 predictors appear to be related to stroke severity either directly or indirectly, it would seem that severe spasticity is predicted by stroke severity. However, we were unable to establish any significant predictors of symptomatic spasticity.

This study has several limitations. The first is the wide range in length of time after stroke onset when patients were assessed. We believe this could have impacted on some of the results, especially those relating to predicting spasticity. Secondly, as this was a cross-sectional study, we are not able to tell when upper limb spasticity occurred. Thirdly, as the study cohort is not representative of the general stroke population, the results should be interpreted with this caveat in mind. Finally, this study did not evaluate the severity of impact of spasticity on upper limb functioning. Knowing this would have given us a better idea of the significance of the symptoms experienced by the patients. We speculate that this failure to distinguish severity of symptoms may have contributed to the inability to establish significant predictors of symptomatic spasticity.

In conclusion, one-third of patients with chronic stroke attending a rehabilitation clinic were found to have symptomatic upper limb spasticity, with passive function the domain most commonly affected. Severity of spasticity was the most important correlate of symptomatic spasticity. LEMI, NIHSS and dysphasia on admission to rehabilitation were significant predictors of severe, but not symptomatic, spasticity.

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