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Research Article

Why the Nine Hole Peg Test should not Disappear from Clinical Stroke Routine

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Abstract

Objectives: To evaluate if the Nine Hole Peg Test (NHPT), a standardized test of hand dexterity contributes to differentiate the risk of post-stroke spasticity.

Materials and Methods: Consecutive patients with first-ever cerebral infarct were included in our prospective study over 2 years and clinically examined within 7 days after the acute stroke event, including increased muscle tone for spasticity and the performance time of NHPT and muscle tone was assessed again at 3 months.

Results: Of 133 patients, 32 developed post-stroke spasticity in 3 months after stroke. The NHPT showed a significantly longer performance time in patients with spasticity (n=32), especially compared to patients with paresis but no spasticity (n=36) (123.9 ± 46.4 vs. 48.5 ± 45.1 seconds; $p<0.01$). The "cutoff" performance time of 25 seconds was effective to differentiate the risk of developing of post-stroke spasticity (sensitivity 60.4%, specificity 100%). In the patients with spasticity, the performance time of NHPT was poorly correlated with the severity of arm paresis.

Conclusions: The NHPT allows excluding the risk of post-stroke spasticity in early phase following stroke. This differentiation allows a subdivision of the patients' cohort, especially in patients with initial mild or moderate paresis of upper extremities, to diminish the patients with the risk of PSS, who need long-term following clinical observation.

Keyword: Nine hole peg test; Stroke; Spasticity; Predictor

Introduction

The instruments for the Nine Hole Peg Test (NHPT) consist of a pin board with nine holes of the same size and the pins inside and a stopwatch. It was firstly introduced by Kellor et al. in 1971 and was one of the most used clinical measures for upper limbs dexterity evaluation among patients with a neurological dysfunction [1,2]. However, its importance in clinical routine has declined considerably in recent times.

The execution of the test is very simple. In the first step is to remove all the pins one by one from a pin board and to place them in a storage box. In the second step all pins - again individually - have to be inserted into the pin board again with the same hand. The time for the execution of both steps is stopped altogether and represents the time result to be determined. Several studies showed its reliability and validity in the test of finger dexterity, also in stroke patients [3-7].

Post-Stroke Spasticity (PSS) has been well known as the one of main difficulties in stroke rehabilitation and there are only symptomatic approaches against it. Identification of predictors and earlier recognition of spasticity to help rehabilitations team recognize, which patients are at risk for PSS to develop, has been therefore suggested to introduce earlier treatment of PSS, e.g. a local therapy with botulinum neurotoxin type A as well as physio- and occupational therapies and possibly better outcomes [8].

Up to now several publications suggested severe paresis (Fugle-Meyer Assessment, Motricity Index, degrees and patterns of paresis as predictor for development of post-stroke spasticity [9-14], however some patients with post-stroke spasticity were not included there, who had limited- but remaining useful motor functions of upper extremities - as shown in the previous studies [9-12,14]. Sommerfeld et al. [15], reported significant difference of the performance of NHPT between patients with spastic and without spastic movement disorder at follow-up post stroke (3 months).

The NHPT as a standardized test of hand dexterity may be an early indicator of spasticity following stroke- at an early stage of this disease. Therefore, our question was whether the NHPT can contribute to differentiate the risk of developing spasticity following stroke, especially in patients with initial not-severe paresis in the acute phase.

Materials and Methods

Patients admitted to the Stroke Unit at the Charité medical university in Germany were consecutively included in this prospective study over a period of 2 years. Inclusion criteria were first-ever ischemic stroke event, >18 year-aged and written inform consent. Patients with previous physical disabilities, aphasia, cognitive disorder, and hemorrhagic stroke event were excluded. The NHPT was part of a standardized clinical evaluation within the first 7 days (T0) of acute stroke event. A follow-up visit was performed after 3 months (T1). A neurologist and a experienced physiotherapist assessed together and discussed the results. The clinical assessment included: muscle strength (BMRC: British Medical Research Council for muscle strength) [16], sensory testing, neglect testing, performance of daily activity of life (Barthel Index [17]), modified Rankin Scale [18]. Muscle tone was assessed using the REPAS (REsistance of PAssive movement Scale), based on Ashworth scale [19]. The NHPT were performed with both hands, affected and non-affected side, measured by stopwatch. The NHPT performance time for inserting 9 pins was limited up to 150 seconds. The unfeasible performance was equated with 150 seconds [7].

Statistics were performed using the "Statistical Package for the Social Sciences" (SPSS) program, Version 21.0 (IBM). T-test, Mann-Whitney U test and χ^2-squared test were applied for the comparison of patients with and without Post-Stroke Spasticity (PSS). The statistical significant results was considered with $p<0.05$.

Results

764 consecutive patients of a Stroke Unit were screened. In total, 133 patients were included. 32 patients (27 at baseline and additionally 5 at 3 months) developed a velocity-depended increase in muscle tone measured as spasticity in the REPAS at baseline (<7 days) or follow-up assessment (3 months) after stroke. In all 133 patients, the performance times for NHPT were recorded on both sides, including all 68 patients with paresis of upper limbs (BMRC <5). The calculation and statistics of the NHPT of the unaffected sides showed equal distribution or normal values as described by Mathiowetz et al. [3] and Oxford Grice et al. [20]. The basic epidemiological data differed not significantly between patients with or without PSS ($p>0.05$) (Table 1a, 1b).

Patients	PSS	no PSS
n	32	101
Age, y	73±10.2	70±11.6
Femal, % (n)	21.9 (7)	23.8 (24)
Paresis % (n)	100 (32)*	35.6 (36)
Sensory loss, % (n)	34.4 (11)	29.7 (30)
Neglect, % (n)	18.7 (6)	3 (3)
BI, mean ± SD	42.5 ± 32.3* º	92.6 ± 16.2
MRS, Median (IQR)	4.0 (4.0-5.0) * º	1.0 (0-1.0)
NIHSS, Median (IQR)	8.5 (4.25-11.75)	0 (0-1)

Table 1a: The demographic data and clinical characteristics of patients.

Patients	no PSS, no paresis	no PSS, paresis
n	36	65
Sensory loss, % (n)	41.7 (15)	23.1 (15)
Neglect, % (n)	2.8 (1)	3.1 (2)
BI, mean ± SD	83.6 ± 22.6	97.5 ± 7.9
MRS, median (IQR)	2.0 (1.0-4.0)	0 (0-1.0)
NIHSS, Median (IQR)	0 (0-1)	1 (0-3.75)

Gs: spastic group; **Gn:** non-spastic group; **Gnn:** non-spastic patients with no paralysis; **Gnp:** non-spastic patients with paralysis; * $p<0.01$ in Gs vs. Gn; º $p<0.01$ in Gs vs. Gnp; **BI:** Barthel Index; **MRS:** Modified Rankin Scale; **NIHSS:** National Institute for Health Stroke Scale; **IQR:** interquartile range 25-75.

Table 1b: The demographic data and clinical characteristics of patients without spasticity.

Based on age-depended NHPT norm values [3,20] and the distribution within our values, the NHPT performance time were arbitrarily divided into 6 grades to create "cutoff value": Grade 1: 0-20 seconds, Grade 2: 20.1-25 seconds, Grade 3: 25.1-30 seconds, Grade 4: 30.1-50 seconds, Grade 5: 50.1-149.9 seconds, Grade 6: 150 seconds.

Statistical analysis showed that NHPT performance time at baseline (T0) was significantly longer in 32 patients with spasticity compared to total 101 patients without spasticity (123.9 ± 46.4 seconds vs. 31.7 ± 30.3 seconds, $p<0.01$) at the affected arm. The NHPT performance time (T0) was also delayed in 36 patients without spasticity but with paresis, but still faster than in patients with spasticity (48.5 ± 45.1 seconds, $p<0.01$). No significant difference was found for the unaffected sides in patients with spasticity versus without spasticity (24.0 ± 4.8 seconds vs. 18.8 ± 7.6 seconds or vs. 24.2 ± 17.0 seconds, $p>0.05$). Even the group of patients with spasticity but not-severe paresis (n=8, BMRC grade 4 and 4+) showed a significantly prolonged NPHT performance time (T0) compared to the group of patients without spasticity and not-severe paresis (n=24, BMRC grade 4 and 4+) ($p<0.05$; Table 2).

	BMRC	**NHPT, seconds**					
	Grade	≤20	≤25	≤30	≤50	<150	150
PSS (n=32), % (n)	0	0	0	0	0	0	56.3 (18)
	1	0	0	0	0	3.1 (1)	9.4 (3)
	2	0	0	0	3.1 (1)	0	0
	3	0	0	0	0	3.1 (1)	0
	4-	0	0	0	0	0	0
	4	0	0	0	3.1 (1)	0	6.2 (2)
	4+	0	0	3.1 (1)	6.3 (2)	6.3 (2)	0
	5	0	0	0	0	0	0
no PSS (n=36), % (n)	0	0	0	0	0	0	11.1 (4)
	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	8.3 (3)	2.8 (1)
	4-	5.6 (2)	0	0	2.8 (1)	2.8 (1)	0
	4	0	2.8 (1)	2.8 (1)	2.8 (1)	2.8 (1)	0
	4+	19.4 (7)	13.9 (5)	11.1 (4)	11.1 (4)	0	0
	5	0	0	0	0	0	0
Total (n=68)		9	6	6	10	9	28
NHPT: Nine-Hole-Peg Test; **BMRC:** British Medical Research Council for muscle strength							

Table 2: The performance time of NHPT and BMRC in the patients with paresis.

No patient (0%) with spasticity (and paresis) performed the NHPT (T0) in 25 seconds, while 15 (41.7%) patients without spasticity but with paresis performed the NHPT (T0) in 25 seconds. The NHPT performance time of >25 seconds showed low sensitivity as a predictor of PSS (sensitivity 60.4%, specificity 100%).

27 (84.3%) patients with spasticity and paresis showed delayed NPHT performance time (T0) of >50 seconds, only 9 (25%) of 36 patients without spasticity but with paresis showed NPHT performance time (T0) of >50 seconds (sensitivity 75%, specificity 84.4%; Figure 1).

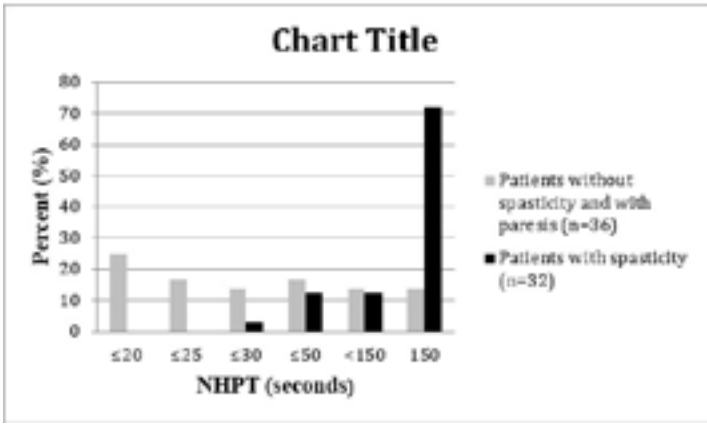

Figure 1: The distribution of performance time of Nine-Hole-Peg test (NHPT).

A good negative correlation between the severity of paresis of upper limbs (BMRC) (T0) and the performance time of NHPT (T0) was found in patients without spasticity but with paresis (-0.87), but only a low negative correlation in patients with spasticity. (-0.66).

Discussion

The NHPT performance time in stroke patients in the acute to early subacute stage of stroke was investigated and was effective to differentiate the risk group of post-stroke spasticity, even though it did not show high predictive value. Several other clinical potential predictors of post-stroke spasticity were investigated at the same time as paresis, Barthel Index, National Institutes for Health Stroke Scale (NIHSS) and sensory loss.

Patients with spasticity showed significantly longer performance time of NHPT in early phase following stroke compared to patients without spasticity, even in patients without spasticity but with paresis ($p<0.01$). At the same time, no significant correlation was found for the performance time of NHPT and the severity of paresis (BMRC) in patients with spasticity, while a strong negative correlation was found for the performance time of NHPT and the severity of paresis (BMRC) in patients without spasticity. It showed that the hand-fingers dexterity assessed by this test was more affected in the patients with spasticity than without spasticity among the patients with same grades of paresis and the development of spasticity in 3 months following stroke could be predicted or detected earlier by using this test. But in our study this test show no high predictive value in comparison with other clinical assessments.

Other suggested predictors such as severe paresis, low Barthel Index, NIHSS, sensory disorder, modified Rankin Scale [9-14], showed higher risk of post-stroke spasticity depending on their severity and it was difficult to predict PSS with them in not-severe affected stroke survivors.

Compared with other known clinical predictors, it will however be more useful to exclude the risk of spasticity followed after stroke, especially in the patients with not-severe paresis, who can at least perform the test partially or completely.

To our knowledge, only one study showed a significantly difference of the performance time of NHPT between patients with and without spasticity at 3 months after stroke, but this study did not assess the NHPT at baseline [15]. Our study is the first study to evaluate the association with the development of spasticity and the affected hand dexterity after stroke.

The cutoff values of the NPHT performance time with 25 and 50 seconds in the early phase following stroke has no high predictive value as a predictor of post-stroke spasticity, although it was significant longer in patients with spasticity than without spasticity in our study.

However, this study has no large size and many patients had no paresis. In acute phase following stroke, the NHPT time could be also limited by other factors as well as hand dexterity.

Conclusion

The NHPT performance time with the cuttoff value of 25 seconds allows the early differentiation of patients with no risk of PSS from patients with risk of PSS at an early stage of stroke disease. Especially it is more useful to exclude the risk of spasticity in stroke patients with not-severe paresis (BMRC 4 to 4+). As a priority, high-risk patients should be closely monitored for spasticity and treated as appropriate. This saves time and costs in clinical stroke routine, especially it will be more useful in the early introduction of botulinum toxin type A in stroke patients who have the risk of developing of post-stroke spasticity recommended by other clinical predictor. The “good old NHPT” is still a clinical instrument, which is fast and inexpensive and has a functional predictive power in post-stroke spasticity. In daily practice it should not disappear from the clinical stroke unit repertoire.

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Conflicts of Interest

Jörg Wissel was a speaker and advisory board member with honorarium for Allergan, Ipsen, Merz, Sintetica and Medtronic. Other authors declare no conflict of interest.

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