Original article

Assessment of spatial neglect among stroke survivors: a neuropsychological study

Mohammed M. J. Alqahtani

King Khalid University, Kingdom of Saudi Arabia

Neuropsychiatria i Neuropsychologia 2015; 10, 3–4: 95–101

Address for correspondence:
Mohammed M. J. Alqahtani, PhD
Clinical Psychologist, King Khalid University
PO Box 376624
Riyadh 11335, Kingdom of Saudi Arabia
tel. +966 558864000
e-mail: mmjbhhal@gmail.com

Abstract

Introduction: Spatial neglect is a common consequence of stroke and an independent predictor of rehabilitation outcomes. Therefore, assessing spatial neglect is very important. The aim of the study was to assess the clinical usefulness of a test battery for the detection of spatial neglect in stroke patients with an inversed reading/writing spatial frame compared to Latin languages on the basis of an Arabic population.
Material and methods: There were 264 stroke survivors admitted to King Fahad Medical City-Rehab Hospital (KFMC-RH), 165 of whom met the inclusion criteria for this study. They were given a battery of neuropsychological tests, including a preliminary assessment of spatial neglect.
Results: The percentage of stroke patients who showed spatial neglect ranged from about 18% to 41%, depending on the tools used. The high prevalence of spatial neglect was detected by the bell cancellation test, while the 5 cm line bisection test showed the lowest prevalence of spatial neglect. The entire neuropsychology battery detected more symptoms of spatial neglect than did any single test, as approximately 54% of patients in this study demonstrated spatial neglect symptoms on at least one test.
Conclusions: The results encourage rehabilitation professionals in Saudi Arabia to use this neuropsychological battery to detect neglect syndrome in stroke survivors with a writing/reading right-to-left-oriented spatial frame. Increased awareness of the potential mediating role of spatial neglect in post-stroke symptoms will facilitate effective diagnoses and better rehabilitation intervention, resulting in better outcomes.

Key words: assessment, spatial neglect, stroke, neuropsychology, cognitive rehabilitation, Saudi Arabia.

Introduction

Spatial neglect is a relatively common attentional disorder (Swan 2001) resulting from brain damage, usually from a stroke but also from other conditions such as tumors or multiple sclerosis (Bowen *et al.* 1999). Spatial neglect is more observable following right hemisphere damage (Stone *et al*. 1993). Symptoms illustrate the dysfunction of several parts of cognitive processing, including initiation of movement, spatial attention and spatial memory (Karnath and Dieterich 2006). Furthermore, these symptoms can be associated with poor motor recovery and poor response to rehabilitation (Rengachary *et al.* 2011). Spatial neglect is one of the most common disorders following stroke, affecting about 25-80% of all stroke survivors (Buxbaum *et al.* 2004; Lee *et al.* 2008).

Special neglect syndrome often occurs after right hemisphere damage and less frequently occurs following damage to the left hemisphere of the brain. The pathology of the left hemisphere damage could cause hemianopia, but patients learn to compensate for this deficit. Despite the fact that patients with left hemisphere damage may have severe language deficits, they are rather aware of the motor loss. On the other hand, not only does the right hemisphere pathology cause neglect, but also patients may be unaware that they have any of these problems (anosognosia), and some patients could even deny deficits of perception or control of movement (Parton *et al.* 2004).

Spatial neglect can be assessed by several scales, such as drawing tests, cancellation tests (Wilson *et al.* 1987), line bisection tests (Marsh and Kersel 1993), and by reading texts and

descriptions of objects. Tests such as drawing, line bisection and cancellation tests are called pencil and paper tests, and are commonly used because they are fast and easy to use (Lopes *et al.* 2007).

Assessing spatial neglect is an important step to improving symptoms, moving toward successful rehabilitation after a stroke (Punt and Riddoch 2006). In severe cases after a severe stroke, spatial neglect is obvious and can be diagnosed by simple observation of the patient in his bed. However, in most stroke cases, spatial neglect is not clinically apparent and specific testing is needed to reveal the disorder (Azouvi *et al.* 2006). Spatial neglect is not an all-or--nothing phenomenon. Clinical symptoms may vary from one patient to the other according to several factors, such as the time and nature of the assessment (Cassidy *et al.* 1998). Therefore, diagnosing spatial neglect is an important goal, and understanding how to improve the symptoms is an important step toward successful rehabilitation after a stroke.

Commonly after right hemisphere damage, neglect patients fail to answer or orient to stimuli in the left side of space. Unlike other languages, Arabic language requires a right-to-left-oriented spatial frame in order for the brain to code correctly different Arabic characters.

Some previous Arabic studies investigated differences between cognitive functions and Arabic or Latin reading/writing (Ibrahim *et al.* 2013; Taha *et al.* 2013). One study which investigated the brain activity during visual word recognition showed that processing connected letter forms does not present any particular difficulty. However, the data presented here show for the first time the results from a stroke population. It is worth taking into account in the current study whether the linguistic differences can modify the spatial neglect symptoms.

As mentioned above, spatial neglect is frequently assessed by the collection of tests called pencil and paper tests. It has not been studied before whether the spatial neglect has a specific mechanism among Arabic patients with right hemisphere damage, especially when we know that they have a right-to-left-oriented spatial frame when they read and write. Therefore, the aim of the study was to assess the clinical usefulness of a test battery for the detection of spatial neglect in stroke patients with an inversed reading/writing spatial frame compared to Latin languages on the basis on Arabic population.

Material and methods

The purposive sampling technique was used to recruit typical patients with definite criteria for exclusion or inclusion as participants. All stroke survivors admitted to inpatient wards from May 2011 to January 2015 at KFMC-RH in Al-Riyadh capital city, Saudi Arabia, were identified. Patients were eligible if they had experienced a confirmed stroke, as evidenced by a clinical diagnosis of stroke during acute-care hospitalization (Cassidy *et al.* 1998).

The inclusion criteria were as follows: patients 1) had experienced a stroke within the last three months; 2) were over 18 years old; 3) obtained a minimum score of 14 on the Glasgow Coma Scale (GCS); 4) obtained a minimum score of 24 on the Montreal Cognitive Assessment (MoCA); and 5) had no history of psychological problems. Patients with significant stroke-related communication or motor impairment, preventing understanding or implementation, were excluded. Those who were medically unstable due to another medical condition such as individuals with Parkinson's disease, dementia or other degenerative diseases of the central nervous system were also excluded. This study was approved by the official review body, King Khalid University. Informed consent was obtained for all participants. Patients were informed that this survey was not related to their treatment program. The right to participate and confidentiality were assured.

In order to perform the assessments, the examiner sat in front of patients and provided the test tools centrally. Patients were requested not to change the tests' positions while performing the tasks. Tasks were always given in the same order, and no time limit was set.

Glasgow Coma Scale (GCS)

The Glasgow Coma Scale was selected to quantify the level of consciousness. The GCS has long been accepted as a means to evaluate level of consciousness, and it has high reliability (Teasdale and Jennett 1974). Patients were presumed to be conscious if they had a score greater than 13 in the GCS. They were defined as drowsy or unconscious if they had a GCS score of 13 or below (Hawkins *et al.* 1995), and were excluded.

Montreal Cognitive Assessment (MoCA)

The MoCA is a brief neuropsychological assessment, designed to detect subjects with cognitive dysfunction with better sensitivity than

other general screening instruments (Hawkins *et al.* 1995).

It is a one-page test with a maximum score of 30 points. The severity levels of the MoCA are: 18-26 = mild cognitive impairment; 10-17 = moderate cognitive impairment; less than 10 = severe cognitive impairment (Rahman and El Gaafary 2009). Patients with a MoCA score of 24 or above were included.

Line bisection tests

The line bisection test is a quick measure to detect the presence of spatial neglect. Line bisection sensitivity depends on the length of the line, with longer lines being more sensitive (Bisiach *et al.* 1983). In this study, four horizontal lines of two different lengths (two 5 cm and two 20 cm), were presented separately on A4-size sheets and placed in front of the patient. The patient was then asked to mark the midpoint of the lines. Stroke patients with spatial neglect are more likely to miss targets toward the contralesional side and often begin to search from the lesional side of the page. Deviation from the true middle was assessed in cm.

The clock drawing test

The clock drawing test was used originally by neuropsychologists as an assessment of parietal lobe function (Critchley 1966) with a sufficient level to detect spatial neglect patients (Parton *et al.* 2004). Patients were required to place the 12 hours in a circle (approximately 10 cm in diameter) drawn by the examiner with the following instructions: "This is a clock face. Please fill in the numbers and then set the time to 10 past 10." A three-level scale was used, with a score of 0 for a normal performance, 1 for the omission of some hours on one side, and a score of 2 for omission of all hours on one side.

The bell cancellation test

In the bell cancellation test (Gauthier *et al.* 1989), stroke patients were asked to circle 35 target bells, presented on a horizontal A4 sheet, along with 280 distractor symbols in a random collection. All symbols were black. The total number of omissions and the variation between left-side and right-side omissions was recorded.

The following instruction was given to patients: "Your task will consist of circling all the bells you find on the sheet I will place in front of you, without missing any of them." The A4 sheet was placed in front of the patient with the black point positioned centrally to the patient, dividing the body into right and left halves.

The A4 paper of the bell cancellation test was equally divided into 7 columns, labeled 1 to 7, left to right. Each column included 40 distractor symbols and 5 targeted bells to be canceled. The omissions in each of the 7 columns were recorded and summed. More errors on the contralateral side than on the lesional side indicated spatial neglect.

The total number of circled bells was recorded, with a maximum score of 35. An omission of six bells or more on the right or left half of the sheet indicated spatial neglect.

Statistical analysis

For investigating spatial neglect among stroke survivors, descriptive analysis was used, along with means, standard deviations and percentages from each method. Cross-tabulations were used to compare scales and subscales, assessing spatial neglect responses.

Results

There were 264 stroke survivors admitted to the rehab wards at KFMC-RH over 45 months; the mean age was 54 and the age range was 34-71 years. Twenty-six patients with consciousness disturbances were excluded, as their GCS was below 13. Also, 53 patients had a MoCA score of 23 or lower, indicating mild cognitive impairment, so they were also excluded from the study. Significant stroke-related communication or motor impairment was reported by 20 patients, who were likewise excluded. The final sample included 165 stroke survivors, of whom 49 were women (29.7%). The final sample was divided into two main groups: right hemisphere stroke (n = 61; 37.0%) and left hemisphere stroke (n = 104; 63.0%). All except five patients (1.0%) were right handed.

Patients' performance on pencil and paper tests are presented in Table 1. Stroke patients who showed spatial neglect ranged from 18.2% to 41.2%. High prevalence of spatial neglect was detected by the bell cancellation test, while minimum prevalence was reported by the line bisection test. In the line bisection test, a midpoint deviation with 5 cm lines was found in 30 patients (18.2%) and with 20 cm lines in 44 patients (26.6%).

The bell cancellation test showed that errors were made in both the left (1, 2, 3) and right (5, 6, 7) columns. However the final analysis showed a continuous increase in errors from the

Table 1. Performance on pencil and paper tests

Test		Mean	SD	Cut-off	Caseness (*n*)
Clock drawing		0.6	1.2	> 0	(35) 21.2%
Line bisection	5 cm	0.8	3.4	> 2.0	(30) 18.2%
	20 cm	1.4	6.7	> 6.5	(44) 26.6%
Bell cancellation test	Omissions, total no.	10.1	7.6	> 6	(62) 37.6%
	Omissions, left vs. right	5.2	4.4	> 2	(68) 41.2%

Table 2. Cross-tabulations and percentages comparing between all pairs of subscales

	Bell cancellation test Omissions, left vs. right (*n* = 68)			Combined type
		Positive +	Negative –	Positive + Positive +
Clock drawing	Negative –	–	40	41.2%
	Positive +	7	28	
Line bisection, 5 cm	Negative –	–	47	30.9%
	Positive +	9	21	
Line bisection, 20 cm	Negative –	–	30	55.9%
	Positive +	6	38	
Bell cancellation test Omissions, total no.	Negative –	–	6	91.2%
	Positive +	0	62	

far lesional side to the far contralateral side. More errors on the contralateral side (mean = 3.1) than the lesional side (mean = 1.9) were found, indicating greater spatial neglect symptoms.

To assess the sensitivity of pencil and paper tests, stroke patients' performance was compared using cross-tabulations in all subscales, in order to obtain the prevalence of spatial neglect according to clock drawing, 5 cm line bisection, 20 cm line bisection, and the bell cancellation test.

As seen in Table 2, when cross-tabulations were used to screen the agreement of spatial neglect assessment between categories of cases, the bell cancellation test detected the highest rate of spatial neglect.

Further quantitative results are presented in Table 1. Drawing the clock face showed additional qualitative results. Stroke patients with spatial neglect started adding the numbers to the clock faces mostly on the lesional side rather than the contralateral side (41.2%). In drawing details, the clock numbers of 1, 2, 3 and 4 or 7, 8, 9 and 10 were mostly shifted opposite the lesional side, away from the correct positions inside the clock face (Fig. 1).

Lastly, the overall picture showed that the entire neuropsychology battery, which here includes clock drawing, 5 cm line bisection, 20 cm line bisection and a bell cancellation test, detected more cases than any single test alone, as 90 stroke patients (54.5%) demonstrated spatial neglect on at least one test.

Discussion

Presumably, this is the first report of spatial neglect in stroke survivors in Saudi Arabia. The current study detected spatial neglect among about 41% of the subjects, which is in agreement with some previous non-Saudi studies (Cassidy *et al.* 1998), but at the same time, it has a lower prevalence of spatial neglect than other previous studies (Stone *et al.* 1991). Prior studies (Zoccolotti *et al.* 1989), however, also found that estimates of spatial neglect in stroke survivors varied with the test used, ranging from 27% to 52%. Only about 20% of stroke survivors had very obvious spatial neglect. In other studies, approximately 40% of left hemisphere stroke patients and 60% to 80% of right hemisphere stroke patients were detected with spatial neglect (Lee *et al.* 2008).

In this study, all subjects were patients in rehabilitation wards, all with recent strokes. As reported in some previous studies (Azouvi *et al.* 2002), this could explain the high rate of spatial neglect in this study. Less recent stroke survivors are less likely to be admitted to the rehabilitation wards at KFMC-RH.

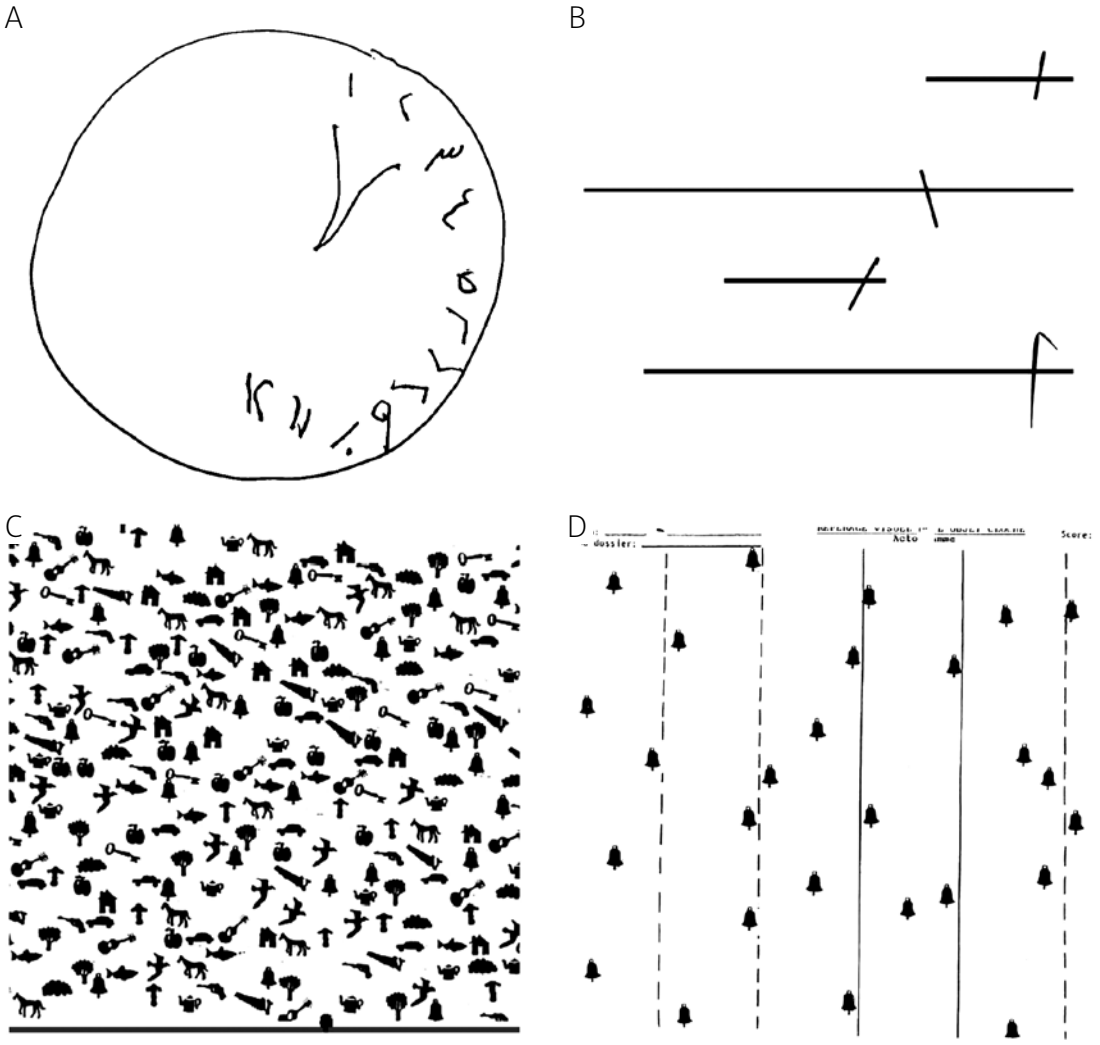

Fig. 1. Samples of patients' performances on pencil and paper tests. A) Clock drawing; B) Line bisection tests; C) Bells cancellation test as well as D) the bell cancellation test's correction sheet

The importance of the current study is that it provides some evidence supporting the use of neuropsychological assessments to detect spatial neglect among stroke survivors. The current study uses the pencil and paper tests for the first time with Arabic stroke survivors. Regardless of having Arabic patients with the brain skill of right-to-left-oriented spatial frame and coding, the performance in general shows the same mechanisms of spatial neglect syndrome after damage of the right hemispheres of the brain.

In this study only nonverbal assessments were used, in order to control any effect of associated language impairments. In fact, at the beginning of this study, some effort was given to reading Arabic text tests, but stroke patients faced multiple difficulties which could reflect other cognitive abilities than spatial abilities alone. As mentioned above, Arabic characters are a special language, very different from several languages. For example, the Arabic alphabet is written and read from right to left and horizontally. The letters of the alphabet can be identified on the basis of shared basic shapes, and can be distinguished from each other by the number and position of dots or the absence of dots, one, two or three, depending on the letter. This type of verbal task to assess spatial neglect among stroke patients seemed to require further attention skills. Therefore, reading Arabic text as an assessment for spatial neglect is not recommended.

Spatial neglect could be assessed inaccurately by asking the patient to comb his/her hair or to reach his left arm with his right hand, for instance. This type of evaluation is qualitative, and cannot be measured quantitatively. Obtaining quantitative results is very important for neu-

ropsychologists, in order to track improvements during and after stroke rehabilitation programs.

As was mentioned previously, the rate of spatial neglect among stroke survivors depends in part on the type of assessments performed. In fact, some stroke patients could show neglect on certain tests but not on others. Therefore, several neuropsychological tools are used to assess spatial neglect, because no single test alone is able to detect symptoms in all patients (Parton *et al.* 2004).

However, since the most frequently used single test is a cancellation test (Azouvi *et al.* 2006), it was used in this study as the primary screening test. Cancellation assessments are more sensitive and may give quantitative scores (Azouvi *et al.* 2006). The current results suggest that bell cancellation tests are useful and sensitive to diagnosing spatial neglect among stroke survivors in Saudi Arabia. This finding is in accordance with previous studies (Azouvi *et al.* 2002; Azouvi 1996), where the bell cancellation test was a sensitive test for detecting spatial neglect.

As mentioned above, a bell cancellation test includes symbols to divert the attention of the subject. The sensitivity of the cancellation assessment varies, according to the presence or absence of symbols diverting stroke patients' attention (Azouvi 1996).

The bisection test, on the other hand, was less sensitive. It is possible that the line bisection test, which needs mostly general attention, is much simpler than a bell cancellation test. Previous studies suggested that, when performing the more complex pencil and paper tests, a stroke patient may have to allocate both general and focal attention (Cohen *et al.* 2010).

Research into spatial neglect is hampered by different methods used for assessment (Maxton *et al.* 2013). Rather than a single standardized test, a neuropsychological battery should be used for assessment, and all aspects of spatial neglect, such as cognitive and attention, should be evaluated. Spatial neglect is hypothesized as a lateralized attention difficulty rather than a sensory problem (Posner *et al.* 1984). Patients with spatial neglect have a global difficulty in deploying attention in space (Robertson 1989). Therefore, attention is factor-biased, regardless of the location of the stroke (Kinsbourne 1993).

It was reported by several studies that when time is limited to brief assessments, the pencil and paper tests tend to reliably capture the spatial elements of neglect (Azouvi 1996), and the combination of a cancellation test with a clock drawing task could be sufficient to detect more than 70% of spatial neglect patients (Azouvi *et al.* 2002).

Despite the presence of a multidisciplinary team of experienced rehabilitation professionals working in a rehabilitation tertiary hospital at KFMC-RH, it seems that spatial neglect is not assessed on a routine basis. Physicians under pressure to discharge patients quickly could be hesitant to involve a systematic spatial neglect screening in the absence of obvious impairments (Sabari 1998). Including simple and short assessments for spatial neglect, such as bell cancellation tests, would be useful.

In many cases, functional and cognitive problems of stroke survivors become more salient when they leave the highly structured hospital environment (Edwards *et al.* 2006). Discharging stroke survivors from inpatient wards, and sometimes from outpatient clinics as well, without evaluating spatial neglect, could be considered unprofessional management of the patient. Stroke survivors who sometimes appear normal may nevertheless have spatial neglect that could prevent them driving or performing the cognitive tasks necessary for a return to daily life.

The current findings support systematic screening for spatial neglect and other cognitive domains known to influence daily life, even when such deficits are not immediately apparent (Sands *et al.* 2003).

Conclusions

The current data revealed that this neuropsychological battery of tests improves the detection of neglect syndrome in stroke patients with a writing/reading right-to-left-oriented spatial frame. Such a battery can be suggested for use before rehabilitation interventions and may enable personalized rehabilitation procedures.

Limitations

The present study is not without limitations. Patients with constructional apraxia may perform poorly on such tasks, showing errors on both the left and right sides of space, even if they do not have any spatial neglect. All of the pencil and paper tasks used to detect spatial neglect can be misleading due to co-existing cognitive and neurological impairments, such as motor deficits, which can often co-exist with spatial neglect (Maxton *et al.* 2013).

The current study acknowledges that there is not a "gold standard" scale for evaluating sensitivity and specificity. The Net Reclassification Index could be suggested as one alternative method in

future studies in order to examine the event and nonevent reclassification and to solve the fact of absence of a gold standard scale (Kerr *et al.* 2014). Finally, all stroke survivors in this study received standard psychological, physical, speech and occupational rehabilitative interventions on the ward. It is uncertain whether the amount of interventions given to patients influenced recovery. This may need further investigation, including control subjects for comparison.

References

1. Azouvi P, Bartolomeo P, Beis JM, et al. A battery of tests for the quantitative assessment of unilateral neglect. Restor Neurol Neurosci 2006; 24: 273-286.
2. Azouvi P, Samuel C, Louis-Dreyfus A, et al. Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke. J Neurol Neurosurg Psychiatry 2002; 73: 160-166.
3. Azouvi P. Functional consequences and awareness of unilateral neglect: Study of an evaluation scale. Neuropsychol Rehabil 1996; 6: 133-150.
4. Bisiach E, Bulgarelli C, Sterzi R, Vallar G. Line bisection and cognitive plasticity of unilateral neglect of space. Brain Cogn 1983; 2: 32-38.
5. Bowen A, McKenna K, Tallis RC. Reasons for variability in the reported rate of occurrence of unilateral spatial neglect after stroke. Stroke 1999; 30: 1196-1202.
6. Buxbaum LJ, Ferraro MK, Veramonti T, et al. Hemispatial neglect subtypes, neuroanatomy, and disability. Neurology 2004; 62: 749-756.
7. Cassidy TP, Lewis S, Gray CS. Recovery from visuospatial neglect in stroke patients. J Neurol Neurosurg Psychiatry 1998; 64: 555-557.
8. Cohen ML, Burtis B, Kwon JC, et al. Action-intentional spatial bias in a patient with posterior cortical atrophy. Neurocase 2010; 16: 529-534.
9. Critchley M. The Parietal Lobes. Hafner Publishing Company, New York 1966.
10. Edwards DF, Hahn MG, Baum CM, et al. Screening patients with stroke for rehabilitation needs: validation of the post-stroke rehabilitation guidelines. Neurorehabil Neural Repair 2006; 20: 42-48.
11. Gauthier L, Dehaut F, Joanette Y. The bells test: a quantitative and qualitative test for visual neglect. Int J Clin Neuropsychol 1989; 11: 49-54.
12. Hawkins GC, Bonita R, Broad JB, Anderson NE. Inadequacy of clinical scoring systems to differentiate stroke subtypes in population-based studies. Stroke 1995; 26: 1338-1342.
13. Ibrahim R, Taha HY, Dabous AA, Khateb A. Electronic reading and writing in spoken and written arabic: a case study. Theory and Practice in Language Studies 2013; 3: 1497-1508.
14. Karnath HO, Dieterich M. Spatial neglect – a vestibular disorder? Brain 2006; 129: 293-305.
15. Kerr KF, Wang Z, Janes H, et al. Net reclassification indices for evaluating risk prediction instruments: A critical review. Epidemiology 2014; 25: 114-121.
16. Kinsbourne M. Orientational bias model of unilateral neglect: Evidence from attentional gradients within hemispace. Unilateral Neglect: Clinical and Experimental Studies 1993; 63-86.
17. Lee BH, Kim EJ, Ku BD, et al. Cognitive impairments in patients with hemispatial neglect from acute right hemisphere stroke. Cogn Behav Neurol 2008; 21: 73-76.
18. Lopes MA, Ferreira HP, Carvalho JC, et al. Screening tests are not enough to detect hemineglect. Arq Neuropsiquiatr 2007; 65: 1192-1195.
19. Marsh NV, Kersel DA. Screening tests for visual neglect following stroke. Neuropsychol Rehabil 1993; 3: 245-257.
20. Maxton C, Dineen RA, Padamsey RC, Munshi SK. Don't neglect 'neglect' – an update on post stroke neglect. Int J Clin Pract 2013; 67: 369-378.
21. Parton A, Malhotra P, Husain M. Hemispatial neglect. J Neurol Neurosurg Psychiatry 2004; 75: 13-21.
22. Posner MI, Walker JA, Friedrich FJ, Rafal RD. Effects of parietal injury on covert orienting of attention. J Neurosci 1984; 4: 1863-1874.
23. Punt TD, Riddoch MJ. Motor neglect: implications for movement and rehabilitation following stroke. Disabil Rehabil 2006; 28: 857-864.
24. Rahman TT, El Gaafary MM. Montreal Cognitive Assessment Arabic version: reliability and validity prevalence of mild cognitive impairment among elderly attending geriatric clubs in Cairo. Geriatr Gerontol Int 2009; 9: 54-61.
25. Rengachary J, He BJ, Shulman G, Corbetta M. A behavioral analysis of spatial neglect and its recovery after stroke. Front Hum Neurosci 2011; 5: 29.
26. Robertson I. Anomalies in the laterality of omissions in unilateral left visual neglect: Implications for an attentional theory of neglect. Neuropsychologia 1989; 27: 157-165.
27. Sabari JS. Occupational therapy services after stroke: Are we providing the right services at the right time? Am J Occup Ther 1998; 52: 299-302.
28. Sands LP, Yaffe K, Covinsky K, et al. Cognitive screening predicts magnitude of functional recovery from admission to 3 months after discharge in hospitalized elders. J Gerontol A Biol Sci Med Sci 2003; 58: M37-M45.
29. Stone SP, Halligan PW, Greenwood RJ. The incidence of neglect phenomena and related disorders in patients with an acute right or left hemisphere stroke. Age Ageing 1993; 22: 46-52.
30. Stone SP, Wilson B, Wroot A, et al. The assessment of visuo-spatial neglect after acute stroke. J Neurol Neurosurg Psychiatry 1991; 54: 345-350.
31. Swan L. Unilateral spatial neglect. Phys Ther 2001; 81: 1572-1580.
32. Taha H, Ibrahim R, Khateb A. How does Arabic orthographic connectivity modulate brain activity during visual word recognition: An ERP study. Brain Topogr 2013; 26: 292-302.
33. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. Lancet 1974; 304: 81-84.
34. Wilson B, Cockburn J, Halligan P. Development of a behavioral test of visuospatial neglect. Arch Phys Med Rehabil 1987; 68: 98-102.
35. Zoccolotti P, Antonucci G, Judica A, et al. Incidence and evolution of the hemineglect disorder in chronic patients with unilateral right brain damage. Int J Neurosci 1989; 47: 209-216.