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SPATIAL NEGLECT IN ACUTE STROKE: THE LINE BISECTION TEST

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ABSTRACT. Line bisection testing was performed on 82 elderly subjects within 14 days of a non-lacunar stroke. The 40 subjects with impaired line bisection were of similar age and pre-stroke dependency as the 42 subjects with normal line bisection but had a more severe current stroke deficit as evidenced by a higher incidence of new hemiplegia, homonomous hemianopia, visual extinction and constructional impairment, and greater power loss. Subjects with impaired line bisection had poorer functional outcome than those with normal line bisection as measured by Barthel activities of daily living scores, walking speed and discharge residence. When subjects with impaired line bisection were divided into two groups according to line bisection error, the severely impaired had worse functional outcome than the mildly impaired. After accounting for motor loss and the ability to draw a house by using logistic regression, line bisection did not contribute significantly to predicting functional outcome.

Key words: cerebrovascular disorders, rehabilitation.

Spatial neglect is among the most disabling features of stroke (5, 7, 10, 15). Subjects with spatial neglect have a lower chance of regaining independence (10) or returning home after discharge from hospital than those free of spatial neglect (7).

There are many tests which assess various aspects of spatial neglect by way of three-dimensional construction, copying standardised drawings or line cancellation. Batteries incorporating a mixture of these tests have also emerged (12). Before adopting such batteries, however, we should pause to ask whether a short and simple test could provide similar information. Unfortunately there are few studies comparing such tests to one another.

Line bisection is a short and simple test of spatial neglect which has often been included in research test batteries of stroke subjects (2, 9, 11, 14).

In this prospective study we tested line bisection within 14 days of nonlacunar stroke. We then compared subjects with normal and impaired line bisection with respect to: 1) Pre-stroke demographic factors and prevalence of prior stroke, 2) indices of current stroke deficit, and 3) functional outcome.

METHODS

All persons aged 60 and above admitted to Waikato Hospital in Hamilton, New Zealand for stroke occurring between 1 January, 1988 and 22 April, 1989 were eligible for this study. The author operates the Waikato Stroke Registry and therefore examines every person aged 60 and above admitted to Waikato Hospital with suspected stroke. Most subjects are first reviewed within three days of stroke onset. The author examines patients at least weekly during their hospital stay and continues outpatient follow-up until 12 months post-stroke.

Stroke was defined as rapidly developing clinical signs of focal or global (if stupor or coma) loss of brain function lasting more than 24 hours or leading to death, with no apparent cause other than cerebral infarction or haemorrhage. Subjects with subarachnoid haemorrhage were excluded.

Probable lacunar syndrome stroke was defined by the presence of one of the lacunar syndromes (1) and the absence of a larger infarction on CT scan, if performed.

CT brain scans were performed on a Siemens Somatom scanner. In the absence of clinical suspicion of brain tumour or subdural haematoma, single-photon emission computed tomography (SPECT scans) were performed using [99mTc]HM-PAO.

Handedness was assessed from statements by the subject and their family. Using this measure of handedness each hemispheric stroke event was classified as either dominant or non-dominant according to clinical and radiographic signs.

As soon as subjects were alert and cooperative, the author administered the following test battery:

1. *Line bisection.* Subjects were first asked to wear corrective lenses. A thick line 200 mm in length was presented. For those with homonomous hemianopia the paper containing the line was placed within their intact visual hemispace. Otherwise it was placed in the midline. The test score was the number of mm that the patient's mark deviated from the true centre. The normal range was taken as 0–6 mm from another study (14).

2. *Mini-Mental State Examination* (3). This includes copying a drawing of dual overlapping pentagons. The sample figure drawn in thick lines measured 90×40 mm. Subjects who drew two pentagons which overlapped were classified as normal.

3. *Copy drawing of a house.* The example drawn in thick

lines measured 80×50 mm and contained a door, two windows, sloping roof and a chimney on the left side with smoke emerging. Subjects who drew all these features without gross neglect were classified as normal.

4. *Number a clockface.* A thick circle 60 mm in diameter was presented. The subject was instructed to view this as a clockface and put inside the circle the numbers corresponding to the hours as they would appear on a clock. Subjects who included all 12 numbers without gross neglect were classified as normal.

5. *Visual fields by confrontation using the examiner's fingers.* A subject was classified as having homonomous hemianopia if he or she had definite homonomous hemianopia at this or any previous medical examination post-stroke.

6. *Visual extinction.* Two simultaneous visual stimuli were presented. If the subject had any suggestion of homonomous hemianopia both stimuli were placed within the intact visual hemispace. Subjects who consistently ignored the left or right stimulus were considered to have visual extinction.

Subjects with mild deficits received this test battery as early as day 1 post-stroke whereas those with more severe deficits were tested later if and when they were able to participate.

Aphasia or dysphasia were said to be present when subjects had a major language disorder however transient following stroke; dysarthria alone was not sufficient.

Minimum power in the affected limbs was chosen as the index of motor loss from stroke. Power was graded on the Medical Research Council Scale (0 = total paralysis to 5 = full power). Power in the biceps and finger abductors were averaged to give a single arm power score. For the leg power in hip extension, knee extension and ankle dorsiflexion were averaged.

The modified Barthel activities of daily living score (Barthel ADL score) was the principal index of dependency and self-care ability (13). Modified Barthel ADL score ranges from 0 (totally dependent, immobile and incontinent) to 20 (independent self-care abilities). Barthel score prior to stroke was calculated from reports by family members. Barthel score post-stroke was measured at week 1, discharge, month 1, 2, 3, 4 and 6.

Walking speed was chosen as the primary index of gait. Gait speed was measured either electronically in a two-metre walkway or with a digital stopwatch over a similar distance. Grossly unsafe walking or gait requiring human assistance was scored as a walking speed of 0. Gait speed was measured weekly during hospital stay, at discharge and at months 1, 2, 3, 4 and 6 post-stroke.

Maximum Barthel score and gait speed represented the highest values achieved by each subject post-stroke.

Residence before and after stroke was classified as either independent or dependent. Subjects living alone or those living with another person but requiring no help in self-care activities such as dressing, toileting, walking or bathing were considered independent. Anyone living in an institution or dependent on a caregiver at home for self-care activities was considered dependent.

New Zealand has two types of institutions for the impaired elderly. Rest homes care for the frail but ambulant with mild to moderate dependency (typical Barthel score 16–20 among our subjects). Long-term hospitals care for the immobile or highly dependent elderly (Barthel 0–12).

The Student's *t*-test and 95% confidence intervals were used to compare group means. The Chi-square test was used to compare proportions.

The assess the relative contribution of line bisection testing to predicting functional outcome we used logistic regression with a maximum likelihood procedure (CATMOD on the SAS system). Two dependent variables were examined separately: 1) maximum Barthel score $\leqslant 12$, a marker of severe dependency used in other rehabilitation research (6), 2) maximum walking speed below 150 mm/sec, a marker of dependent ambulation (4).

The Waikato Hospital Research Committee approved the trial.

RESULTS

During the 16-month study period there were 261 stroke events recorded in the Waikato Stroke Registry. One hundred twenty-five subjects could not or did not perform line bisection; half of these being too ill and dying within three weeks of stroke and the other half surviving at least three weeks but remaining too apraxic to perform line bisection. After excluding a further 39 subjects with probable lacunar stroke, 14 subjects who performed line bisection after day 14 and 1 subject lost to follow-up before full recovery, there were 82 non-lacunar stroke events involving 79 different subjects (three subjects each had two stroke events). The 50 men and 32 women included in the study had a mean age of 75.1 ± 6.4 years. Eighty were living at home at the time of stroke; only two were living in institutions.

Forty-two subjects bisected a line normally (i.e. 0–6 mm error). They were of similar age as the remaining forty with impaired line bisection (Table I). Men comprised three-fifths of both groups. The subjects were generally independent prior to stroke, as measured by Barthel ADL score and pre-stroke residence (Table I). One-fifth of subjects in both groups had a stroke prior to the current one.

The mean delay between stroke onset and line bisection testing was similar in the two groups, averaging 5.5 ± 3.5 days.

CT scans were performed on 28 subjects a median of 6 days post-stroke. Twenty per cent of scans failed to show a stroke lesion. Two subjects with nondiagnostic CT scans had subsequent SPECT scans which showed ischemia in the appropriate region. SPECT was used rather than CT if the clinical presentation raised no question of a disorder other than stroke. In total, 23 subjects had SPECT scans; only two such scans failed to demonstrate ischemia in the appropriate region.

Table I. *Comparison of subjects with normal and impaired line bisection with respect to pre-stroke characteristics*

CI (95% confidence intervals) reported for mean differences between groups. Chi-square test used to compare proportions

	Normal	Impaired	CI
n (M/F)	42 (26/16)	40 (24/16)	–
Age	75.0±7.0	75.2±5.8	−3.0 to +2.6
Pre-stroke Barthel score	19.9±0.6	19.4±2.0	−0.2 to +1.1
Pre-stroke residence			
Independent	39/42	36/40	–
Institution	1/42	1/40	–
Prior stroke	9/42	9/40	–

CT or SPECT scans were performed on 64% of the normal group and 55% of those with impaired line bisection (p=NS). Sixty-five percent of study subjects had either a CT scan, SPECT scan or autopsy of the brain.

Considering only those hemispheric strokes which could be classified as involving chiefly the dominant or non-dominant hemisphere, impaired line bisection was associated with non-dominant hemisphere stroke (Table II). Because 79 of 82 subjects were right handed, the ratio of subjects with new left versus right hemiplegia is another measure of non-dominant hemisphere stroke. Among those with normal line bisection left and right hemiplegia were evenly distributed whereas among those with impaired line bisection left hemiplegia was three-fold more common (Table II).

A similar percentage of subjects in both groups were alert on admission (Table II). New hemiplegia, however, was more common among those with impaired line bisection and this was reflected in their significantly lower arm power ($p<0.05$, Table II).

Homonomous hemianopia and visual extinction were two and three-fold more common in those with impaired line bisection compared to those with normal line bisection ($p<0.05$, Table II). Likewise they had significantly worse constructional abilities, as measured by copying drawings and numbering a clockface (Table II).

Mini-Mental State Score and the incidence of apha-

Table II. *Comparison of subjects with normal and impaired line bisection with respect to indices of current stroke deficit*

CI represents 95% confidence intervals for differences between means

	Normal	Impaired	CI
Alert on admission	35/42	34/40	–
New hemiplegia	24/42*	34/40	–
Left/right hemiplegia[a]	13/11	25/8	–
Non-dominant/dominant hemisphere	15/20	26/13	–
Minimum arm power	3.37±1.79*	2.21±1.96	0.27 to 2.05
Minimum leg power	3.64±1.66	2.86±1.91	−0.01 to 1.57
Homonomous hemianopia	12/42*	22/40	–
Visual extinction	8/42**	22/40	–
Numbers clockface	28/42**	13/40	–
Copies house drawing	18/42**	3/40	–
Copies pentagons	18/42*	7/40	–
Mini-Mental State Score	22.3±6.3	19.9±7.1	−0.6 to +5.4
Aphasia/dysphasia	11/42	9/40	–

[a] Excluding subjects with bilateral weakness.
* $p<0.05$. ** $p<0.01$.

Table III. *Comparison of subjects with normal and impaired line bisection with respect to stroke outcome, as measured by length of stay, discharge residence, Barthel ADL and walking speed*

CI represents 95% confidence intervals for differences between means

	Normal	Impaired	CI
Length of stay	25.5±21.7	35.8±25.1	−20.7 to +0.05
Discharge residence			
Died	4/42	4/40	–
Independent	27/38*	16/36	–
Institution	3/38***	16/36	–
Long-term hospital	1/38**	11/36	–
Barthel ADL score			
Month 1	17.5±5.2** (n=39)	13.7±6.5 (n=38)	1.1 to 5.9
Month 3	18.6±3.5** (n=34)	14.7±6.1 (n=28)	1.4 to 6.4
Discharge	18.9±3.2** (n=38)	15.1±5.9 (n=36)	1.6 to 6.0
Maximum	18.5±3.9** (n=42)	15.1±6.0 (n=40)	1.2 to 5.6
Walking speed (mm/sec)			
Month 1	675±434** (n=37)	388±416 (n=36)	94 to 480
Month 3	739±451** (n=30)	354±387 (n=27)	161 to 422
Discharge	682±387** (n=38)	408±422 (n=35)	85 to 463
Maximum	799±462** (n=42)	486±441 (n=40)	113 to 513

* $p<0.05$. ** $p<0.01$. *** $p<0.001$.

sia or dysphasia were similar in the two groups (Table II).

Turning to stroke outcome, two-thirds of subjects were admitted to the stroke rehabilitation unit (69% of the normal group and 62% of those with impaired line bisection). Combined length of stay in the acute and rehabilitation wards was on average 40% greater in those with impaired line bisection (p=NS, Table III). Hospital mortality was 10% in both groups. Among hospital survivors discharge to an independent residence was significantly more common in the normal group compared to those with impaired line bisection (Table III). Institutional placement was 5.5-fold more common in the impaired group ($p<0.001$) and long-term hospital placement was 11.5-fold more common ($p<0.01$, Table III).

Functional outcome was much poorer among subjects with impaired than with normal line bisection, as measured by Barthel ADL scores and walking speed at months 1, 3, discharge and maximal recovery (Table III).

To clarify the relationship between impaired line bisection and functional outcome we divided subjects with abnormal line bisection into two subgroups of nearly equal size: mildly impaired (error 7–15 mm) and severely impaired (error of at least 16 mm). The 21 mildly impaired subjects were of similar age to the 19 severely impaired subjects. Functional outcomes were best in the normal group, intermediate in the mildly impaired and worst in the severely impaired.

Logistic regression was then performed using the following independent variables: age, presence or absence of new hemiplegia, arm power, leg power, line bisection normal or impaired, presence or absence of homonomous hemianopia, presence or absence of visual extinction, Mini-Mental State Score, and the ability or inability to perform the three drawings. The only significant predictors of maximum Barthel score ≤ 12 were new hemiplegia ($p<0.001$), low arm power ($p<0.01$) and inability to copy a drawing of a house ($p<0.001$). Line bisection error did not contribute significantly to the model. We then examined the subset of 58 subjects with new onset of hemiplegia because all subjects lacking hemiplegia had a maximum Barthel score above 12. The only significant predictive factors in this subgroup were low arm power ($p<0.01$) and inability to draw a house ($p<0.001$). Once again line bisection error did not contribute significantly to the model. Finally we examined the subset of 50 subjects with new hemiplegia who could not draw a house because those subjects able to draw a house all had good outcomes. The only significant predictor of maximum Barthel score in this subgroup was low arm power ($p<0.01$). Line bisection error did not contribute significantly to the model.

Using maximum walking speed $\leqslant 150$ mm/sec as the outcome variable with logistic regression, results were much the same; the presence of hemiplegia, low arm power and the inability to draw a house significantly predicted poor mobility. Line bisection did not contribute significantly to the model.

DISCUSSION

Line bisection within two weeks of a non-lacunar stroke proved to be a valid and useful test for spatial neglect. Impaired line bisection was strongly associated with homonomous hemianopia, visual extinction and impaired ability to copy drawings or number a clockface.

As in other studies (5), the incidence of spatial neglect was higher after nondominant than after dominant hemisphere stroke.

Subjects with spatial neglect as evidenced by impaired line bisection had significantly lower arm power and a significantly higher incidence of new hemiplegia than those with normal line bisection. Logistic regression showed that new hemiplegia, low arm power and inability to copy a drawing of a house were significant predictors of poor functional outcome as measured by maximum Barthel score and maximum walking speed. Line bisection error did not contribute significantly to predicting functional outcome in any of the patient subgroups tested. Thus, line bisection should be used to detect spatial neglect rather than to predict functional outcome. Inability to copy a drawing of a house, a measure of constructional impairment, independently predicted functional outcome and could therefore be used in preference to line bisection for selecting candidates for rehabilitation.

Results from this study can be applied to similar populations of elderly subjects admitted to hospital following a non-lacunar stroke. We did not study subjects with lacunar stroke because spatial neglect is much less frequent following lacunar than non-lacunar stroke; any comparison of subjects with and without spatial neglect would therefore be guaranteed to show worse outcome among those with neglect due to their much greater incidence of non-lacunar stroke.

Although line bisection testing has been included in many studies of acute stroke (2, 9, 11, 14) we could find no reports comparing initial line bisection to subsequent Barthel ADL score and walking speed during the first six months post-stroke. It has been shown, however, that line cancellation performed within 48 hours of stroke predicts functional outcome (5).

The optimal method for performing line bisection is unknown. Line length in published studies has varied from 65 to 240 mm (8, 9, 14). The position of the line relative to the subject has also varied from study to study. Line position is important because in a study of six subjects with non-dominant right hemisphere stroke the line bisection error was lowest when the line was positioned to the right of the subjects' midline, intermediate when positioned in the midline and highest when placed to the left of the subjects' midline (8). In the present study the line was positioned in the patients' midline unless there was hemianopia, in which case it was placed within the intact visual hemispace.

The optimal cutoff for line bisection testing is also unknown and must no doubt depend on both test method and timing post-stroke. Our cutoff, chosen from normal controls in another study (14), represented only 3% of line length. Other studies have selected much higher cutoffs (9). Most of our subjects were tested within six days of stroke. Line bisection error in the minority of subjects tested 7–14 days post-stroke might have been greater had it been measured during the first six days after stroke.

In conclusion, line bisection is a useful screening test for spatial neglect following stroke. Because line bisection takes less than 15 seconds to complete it can be easily incorporated into routine stroke evaluations. Subjects with impaired line bisection have poorer functional outcome as measured by Barthel ADL score, walking speed and discharge residence than those with normal line bisection. Because line bisection did not independently predict functional outcome, it should not be used to select candidates for rehabilitation units.

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