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Disclosures:

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ORIGINAL RESEARCH ARTICLE

Comparing Consequences of Right and Left Unilateral Neglect in a Stroke Rehabilitation Population

ABSTRACT

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Objective: This article details right and left unilateral neglect (UN) in a stroke rehabilitation population.

Design: This prospective observational cohort study documented hemipersonal neglect and hemispatial neglect in 309 of 325 stroke rehabilitation patients consecutively admitted over a 28-month period. Shoulder-hand complications, safety concerns, length of stay, discharge function, and discharge destination were documented.

Results: Of the 85 with right UN and 113 with left UN, 17.7% had expressive aphasia, and 17.7% had mixed or receptive aphasia. Hemispatial neglect was associated with hemianopsia (29.2% and 31.8% for right and left, respectively). Having both hemipersonal neglect and hemispatial neglect was related to greater safety risk (46.9% *vs.* 24.3%), greater incidence of shoulder-hand complications (28.3% *vs.* 9.9%), lower FIM scores (>10 points lower), longer length of stay (8 days), and less likelihood of discharge to home (67.3% *vs.* 87.4%) than subjects without UN. Results were similar for those with right and left UN.

Conclusions: Right and left UN occur after stroke, can be detected even in the presence of aphasia, and are associated with shoulder-hand problems, lower discharge function, and lower likelihood of discharge home. Having both hemispatial neglect and hemipersonal neglect impacts people more than having either type of UN alone.

Key Words: Cerebrovascular Accident, Unilateral Neglect, Perceptual Disorders, Outcome Assessment

Unilateral neglect (UN) or inattention primarily to the left side of the body and of the environment has been a well known clinical result of right hemispheric stroke.[1,2] The presence of UN seems to predict poorer outcomes after stroke.[3] Occasional case reports and series of right-sided UN have also been published.[4–7] One prospective study in the literature[7] documented the incidence of left UN in patients with right hemisphere lesions as 42%, as compared with an incidence of right UN in patients with left hemisphere lesions of 8%, whereas another indicates less of a difference between the incidences of right and left UN after stroke.[3] Right-sided UN after stroke is not infrequent,[8] and may occur at a rate of approximately a half to two-thirds that of left UN after stroke.[9–11] Some postulate that right UN after stroke may be under-detected because of the presence of aphasia.[12] Both right and left UN have been detected in children, despite difficulty in assessment.[13]

The term "neglect" in the literature seems to be used to indicate a number of different entities. The UN syndrome is known by several terms: "unilateral spatial neglect," "spatial" or "hemispatial inattention," "visual neglect, "lack of body awareness," "gaze preference," "visual extinction," "personal neglect," "behavioral neglect," "motor neglect," "hemi-inattention," "inattention," "inattention to person," "peri-personal neglect," "inattention" to near- and far-extrapersonal space, and "allesthesia."[9,13–18] Many use the term inattention to imply a lesser severity of impairment. For the remainder of this article, the term "UN" will be used as the umbrella term described above.

Detection of UN may relate to timing after stroke, as there is one report of less persistence of right UN as compared with left UN.[19] Although one prospective study[7] did not find any impact upon function or length of rehabilitation, others have reported left-sided UN syndromes as associated with poorer outcome, partly due to poor recognition and management of visuospatial deficits.[1,20] One study attempted to document the influence of visual UN on stroke rehabilitation.[21] Unfortunately, perhaps because of the lack of awareness of right UN at the time, no distinction was made in the report between right and left UN. A better understanding of the effects of right compared with left UN after stroke is required, to determine whether previously published literature on left UN can be generalized to right UN, to assist individual patients and their families through the rehabilitation process.

Different types of UN have been documented, namely, to auditory, visual, and somesthetic input.[14] Our study focused on UN of person and/or environment, including near- and far-extrapersonal space. Currently, there exist many theories of UN, and most of them suggest a deficit in attention due to brain injury.[1] An example is Kinsbourne's orientational bias model[22] of UN, which proposes that brain hemispheres contain contralaterally oriented attentional processors, which if impaired, leads to UN or inattention. Many authors believe that the right hemisphere has a special role in attention of extrapersonal space in both hemispaces,[23–25] particularly the frontal and parietal lobes.

In rehabilitation, impairments that cause safety concerns are important to recognize as such persons needing supervision. Also, one medical complication thought to be caused by the presence of UN is shoulder pain,[26] and subsequent complex regional pain syndrome, also known as shoulder-hand syndrome.[27] Perhaps this is because there is more trauma to the neglected hemiparetic extremity. If so, one might expect to see more shoulder-hand problems with hemipersonal neglect (HPN) as compared with hemispatial neglect (HSN). This article examines the relationship of UN with shoulder-hand problems and safety risk, and outcomes such as change in FIM score, length of stay (LOS), discharge function, and discharge destination (DD) from an inpatient stroke rehabilitation unit. Previous work by these authors has already identified stroke impairment factors associated with these outcomes using multivariable regression.[11] This article expands on the findings specific to UN to person or extra-personal space, and the complications associated with these deficits.

METHODS

This "real-world"[28] observational case series compares incidence and characteristics of subjects with right and left UN in an inpatient stroke rehabilitation unit, and summarizes available computerized tomography (CT) imaging reports. Institutional ethics approval for this observational research study was obtained through the hospital ethics committee. Data were obtained from a cohort of 313 consecutive stroke patients admitted for inpatient stroke rehabilitation over a 2-yr period at a tertiary rehabilitation centre in British Columbia, Canada. Admission criteria have been previously described.[11] Subjects had to be medically stable, meaning that no new medical treatments were being planned in the acute hospital; meeting nutritional intake requirements; and ready to participate in a rehabilitation program, with ability to follow gestural or verbal commands, sit unsupported at the edge of a bed for 30 secs, sit in a chair for at least 2 hrs, and participate in several 30-min therapy sessions per day. As this was a tertiary rehabilitation centre, and referrals to the stroke rehabilitation unit were often delayed, strokes must have occurred within 6 mos of acute

hospital admission. Those who could not participate in active rehabilitation were excluded. These included persons with anosognosia, defined using a conservative criterion as described by Baier and Karnath,[29] and those who could not communicate at least through understanding and initiating of gestures. Most patients had imaging of their head before admission. Available CT scan reports for these subjects were documented.

All subjects underwent active stroke rehabilitation by an interdisciplinary team, receiving daily intervention during the week. Team members included patients and their families, social workers, pastoral care workers, speech-language pathologists, a dietitian, occupational therapists, physiotherapists, a recreational therapist, nurses, a physiatrist, family physicians, and volunteers. Individual patient goals were identified, and weekly goals were set during the inpatient rehabilitation period. Presence or absence of UN was assessed by experienced stroke rehabilitation team members, including a physiatrist, occupational therapists, physiotherapists, recreational therapist, and nurses. For the purposes of this article, the terms "HSN" and "HPN" are used for UN or inattention of the environment and of person, respectively. A visual and tactile extinction examination[3] was completed for each subject by the physiatrist. Gaze preference, if present, was noted as HSN of the contralateral side. Care was made to distinguish UN of extra-personal space from hemianopsia in assessments. For this, confrontational testing was used, and HSN was documented when bilateral stimuli placed within intact portions of subjects' visual fields led to preferential detection on one side.

Occupational therapists conducted standard batteries of paper and pencil tests described elsewhere—line bisection, clock-drawing, Rivermead Perceptual Assessment Battery testing, reading of sentences, reading of a menu, star, line and Bell's cancellation tests,[8,30–32] as well as a light board examination, during which each subject sat in front of a 180-degree screen with lights scattered throughout and were asked to identify flashing lights; lights were turned on in one or both visual fields during testing. All subjects were assessed with the light board. HSN was reported by team members when asymmetric errors were detected with the visual light board assessments, on paper and pencil tests according to reported criteria,[33] when food was consistently left on one side of their plate, or when subjects were observed to bump repeatedly into objects on one side of their bodies. Though the entire battery was available to therapists, if they documented HSN through two different standardized and validated tests, they generally did not continue assessment for HSN. They also assessed behavioral UN in kitchen assessments and during functional task assessments.

Subjects were assessed for aphasia by speech-language pathologists, according to the Western aphasia battery,[34] and classified as having expressive, receptive, or mixed (both) aphasia. Aphasic patients were assessed through the use of gestures and verbal instructions. Because of the communication admission criterion, difficulties in assessing for the presence of HSN or HPN only occurred in two subjects with receptive aphasia, and were generally not encountered, as subjects were able to gesture according to instructions, during testing. Observed HPN in persons with aphasia was documented by team members, as for other subjects. Therapists and nurses assessed behavioral UN during mobilization or during functional tasks such as eating, grooming, and other activities on the ward and documented observations in the chart.

HPN was documented when lack of awareness of one side of the subject's own body was observed and documented by a member of the team. There is a lack of standardized tests for HPN, other than tactile extinction, which had to be present in addition to reported observations by team members. One report suggests that such behavioral assessment of UN in daily life is more sensitive than any paper and pencil test.[16]

If any team member indicated the presence of UN, the subject was assessed further by other team members, and for the purposes of this real-world study, UN was documented if confirmed by more than one team member. Each subject with HSN must have demonstrated visual extinction, and each subject with HPN must have demonstrated tactile extinction, as tested by the physiatrist, in addition to observations made by other team members. Functional severity of UN varied from mild to severe, but was not rated, because of the lack of a well accepted clinical rating scale for UN.

Shoulder-hand problems and complex regional pain syndrome of the ipsilateral upper extremity to the side of UN were diagnosed by the physiatrist, whose formal clinical training included diagnosis of such conditions. All 55 subjects with shoulder-hand problems also had ipsilateral hemiparesis (47.3% had right hemiparesis, and 52.7% had left hemiparesis). Forty-four (80%) had some form of UN, whereas 11 (20%) had no UN. Another 251 with hemiparesis did not develop shoulder-hand problems. Altogether, 17.3% of those with right hemiparesis had shoulder-hand problems, whereas 19.1% of those with left hemiparesis had shoulder-hand problems.

Examples of safety concerns in persons with UN included documented collisions with objects or people and injury to the unattended side of the body, accompanied with a lack of insight as to the

cause of the injury. Safety risk was documented in patient charts by members of the rehabilitation team when subjects were noted to injure themselves on the side of UN, put themselves at risk of falling, or manage equipment unsafely due to UN and appeared to have limited insight as to such risks.

LOS was documented. A global measure of discharge function, the FIM,[35] was also collected at admission and upon discharge. Change in FIM was calculated by subtracting the admission from the discharge scores, so that positive values represent improvement. DD, collected as "home" or "other" (institutional care) was noted, because these categories seemed to be the most important outcome for patients and their families.

Statistics

Data were entered into an Excel spreadsheet, and imported into SPSS (Version 14.0, SPSS Incorporated, Chicago, IL, 2005) for analysis. Following descriptive analyses (frequencies, means, standard deviations), independent samples *t* tests and one-way analysis of variance were used to examine the association between categorical variables and the linear variables, including age, LOS, admission FIM, discharge FIM, and change in FIM. For the analysis of variance, Tukey's post hoc tests were used to identify the significant between-group differences. χ^2 tests (Fisher's exact or Pearson's as appropriate) were used to examine the association between categorical variables and the DD.

RESULTS

CT reports for those with UN are shown in Table 1. Imaging reports of those with right UN reported involvement of the following brain areas: deep white matter, thalamus, basal ganglia (caudate, putamen), internal capsule, pons, corona radiata, insula, subinsular areas, and all cortical areas (frontal, parietal, temporal, occipital, primarily in the left hemisphere). Those with left UN involved similar areas, with the exception of cerebellar lesions, which were not reported for any of the subjects with right UN. A higher percentage of CT scan reports indicated deep structure (subcortical) involvement as opposed to cortical involvement for both right and left UN (see Table 1 for details). Four reports indicated bilateral hemispheric involvement; of these, two had no UN, one had left HPN and HSN (basal ganglia), and one had right HPN and HSN (parieto-occipital).

Of the 313 eligible patients, 4 had bilateral neglect impairments: 1 with right HPN and left HSN, 1 with left HPN and right HSN, and 2 with both right and left HSN. The person with right HPN and left HSN had a CT scan report indicating mass effect, with deep and cortical areas involved, whereas the CT scan report of the person with left HPN and right HSN indicated involvement of deep structures. The two people with both left and right HSN had lesions in deep and cerebellar areas, respectively. Given the small numbers of these bilateral impairments, they were excluded from further analyses.

The remaining 309 subjects included 161 men and 148 women with a mean age of 75.5 ± 8.1 yrs. They were equally represented with respect to hemisphere affected. Time since stroke onset ranged from 7 to 152 days (mean 37 ± 22.5 days).

TABLE 1 Summary of counts and percentages of CT head reports, by category

Category	No Imaging	Normal or NAD	Cortical	Deep	Cerebellar	Other
Overall (n = 309)	20 (6.5)	45 (14.6)	57 (18.4)	109 (35.3)	14 (4.5)	64 (20.7)
No UN (n = 111)	5 (4.5)	22 (19.8)	18 (16.2)	47 (42.3)	6 (5.4)	13 (11.7)
Right HPN and right HSN (n = 45)	4 (8.9)	1 (2.2)	14 (31.1)	15 (33.3)	0 (0.0)	11 (24.4)
Left HPN and left HSN (n = 68)	3 (4.4)	10 (14.7)	12 (17.6)	16 (23.5)	3 (4.4)	24 (35.3)
Right HPN only (n = 13)	2 (15.4)	1 (7.7)	3 (23.1)	4 (30.8)	0 (0.0)	3 (23.1)
Left HPN only (n = 6)	1 (16.7)	0 (0.0)	0 (0.0)	4 (66.7)	0 (0.0)	1 (16.7)
Right HSN only (n = 27)	2 (7.4)	4 (14.8)	3 (11.1)	13 (48.1)	0 (0.0)	5 (18.5)
Left HSN only (n = 39)	3 (7.7)	7 (17.9)	7 (17.9)	10 (25.6)	5 (12.8)	7 (17.9)
Any right UN (n = 85)	8 (9.4)	6 (7.1)	20 (23.5)	32 (37.6)	0 (0.0)	19 (22.4)
Any left UN (n = 113)	7 (6.2)	17 (15.0)	19 (16.8)	30 (26.5)	8 (7.1)	32 (28.3)
HSN only (n = 66)	5 (7.6)	11 (16.7)	10 (15.2)	23 (34.8)	5 (7.6)	12 (18.2)
HPN only (n = 19)	3 (15.8)	1 (5.3)	3 (15.8)	8 (42.1)	0 (0.0)	4 (21.1)
Both HSN and HPN (n = 113)	7 (6.2)	11 (9.7)	26 (23.0)	31 (27.4)	3 (2.7)	35 (31.0)

The P values below indicate whether there is a significant difference in the CT findings between any of the categories (excluding No UN), but the χ^2 tests do not further define the specific between-category differences.

P value for the different CT findings for the six categories is $P = 0.065$, but this should be interpreted with caution because of the large number of low-frequency cells. The P value for right *vs*. left is $P = 0.023$. The P value for HSN, HPN, or both is not significant ($P = 0.193$).

CT, computerized tomography; HSN, hemispatial neglect or unilateral neglect of the environment; HPN, hemipersonal neglect, or unilateral neglect of person; N, Normal; NAD, No abnormalities detected; Other, includes vague reporting, mass effect, both cortical, and deep structures.

TABLE 2 Number (%) with Aphasia in the presence of UN (significance testing presented below the table)

Category	No Aphasia	Expressive Aphasia	Receptive Aphasia	Mixed Aphasia
Overall (n = 309)	208 (67.3)	48 (15.5)	2 (0.6)	51 (16.5)
No UN (n = 111)	80 (72.1)	13 (11.7)	0 (0.0)	18 (16.2)
Right HPN and right HSN (n = 45)	14 (31.1)	13 (28.9)	1 (2.2)	17 (37.8)
Left HPN and left HSN (n = 68)	60 (88.2)	7 (10.3)	0 (0.0)	1 (1.5)
Right HPN only (n = 13)	8 (61.5)	2 (15.4)	0 (0.0)	3 (23.1)
Left HPN only (n = 6)	6 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Right HSN only (n = 27)	8 (29.6)	8 (29.6)	1 (3.7)	10 (37.0)
Left HSN only (n = 39)	32 (82.1)	5 (12.8)	0 (0.0)	2 (5.1)
Any Right UN (n = 85)	30 (35.3)	23 (27.1)	2 (2.4)	18 (16.2)
Any Left UN (n = 113)	98 (86.7)	12 (10.6)	0 (0.0)	30 (35.3)
HSN only (n = 66)	40 (60.6)	13 (19.7)	1 (1.5)	12 (18.2)
HPN only (n = 19)	14 (73.7)	2 (10.5)	0 (0.0)	3 (15.8)
Both HSN and HPN (n = 113)	74 (65.5)	20 (17.7)	1 (0.9)	18 (15.9)

The P values below indicate whether there is a significant difference in type of aphasia between any of the categories (excluding No UN), but the χ^2 tests do not further define the specific between-category differences.

P value for the different levels of aphasia for the six categories is $P < 0.001$, but this should be interpreted with caution because of the large number of low-frequency cells. The P value for right *vs*. Left is $P < 0.001$. The P value for HSN, HPN, or both is not significant ($P = 0.950$).

HSN, hemispatial neglect; UN, unilateral neglect; HPN, hemipersonal neglect.

Eighty-five subjects (28%) had right UN, whereas 113 (37%) had left UN. Mean age for the group without UN was 77.0 yrs, the group with right UN, 75.4 yrs, and that with left UN, 74.2 yrs ($P = 0.031$ for the difference between the group without UN and those with left UN). Looking at the association between hemianopsia and UN, overall, 24.7% of those with right UN also had right hemianopsia, whereas 30.1% of those with left UN also had left hemianopsia. Looking more closely at subtypes, 29.2% of those with right HSN had right hemianopsia, and 31.8% of those with left HSN had left hemianopsia. Interestingly, those with right HPN did not have hemianopsia, but some with left HPN had right-sided hemianopsia (16.7% right hemianopsia, 0% left hemianopsia); these patients had CT scan reports indicating deep structure involvement in one hemisphere.

Table 2 describes associations with aphasia. 15.5% of all subjects had expressive aphasia, whereas 16.5% had mixed aphasia, and two subjects had receptive aphasia. Of the 198 of 309 who had any form of UN (right, left, HSN, HPN, or both), 128 (64.6%) had no aphasia, 35 (17.7%) had expressive aphasia, 2 (1.0%) had receptive aphasia, and 33 (16.7%) had mixed aphasia, as determined by speech-language pathologists. Of those with right UN 64.7% demonstrated aphasia, whereas only 13.3% of those with left UN demonstrated aphasia; these patients had left HSN, whereas no subjects with left HPN demonstrated aphasia. Of those with expressive aphasia 57.9% had right UN, and 25.0% had left UN. Both the subjects with receptive aphasia had right UN. Of those with mixed aphasia, 58.8% had right UN, and 5.9% had left UN.

Paired samples t testing showed significant improvement in FIM scores between admission and discharge for all impairment categories ($P < 0.001$ for all but left HPN, for which $P = 0.005$). The results of the one-way analysis of variance to compare the LOS and FIM data for the various impairment groups are presented in Table 3. Subjects with right UN had significantly lower admission FIM scores when compared with those without UN. In this cohort, those with right HSN had lower FIM scores than those with left HSN. Subjects with HPN seemed to have lower FIM scores than those with only left HSN or no UN. Admission and discharge FIM scores for those with both HSN and HPN were significantly lower than for the other groups, but FIM gains were not different in this group as compared with those with neither HSN nor HPN (however a longer LOS was seen for the group with both HSN and HPN, as compared with the HSN only group, and with the group without UN). Those with HPN showed larger FIM gains than those with HSN. Discharge FIM scores were significantly lower for those with either right or left UN, but overall FIM gains were similar between all groups (right UN, left UN, and no UN). There were significant between-group differences for both admission and discharge FIM ($P < 0.001$ for both); differences that attained statistical significance are provided as a footnote to Table 3. Though those with left UN differed from right UN (mean change of 14.5 and 17.9, respectively, $P = 0.045$), having either left UN or right UN was not associ-

TABLE 3 Mean (standard deviation) for linear variables, by category

Category	Age	Admission FIM Score	Discharge FIM Score	Change in FIM Score	Length of Stay
Overall (n = 309)	75.5 (8.1)	87.9 (17.3)	104.3 (16.7)	16.4 (10.0)	54.7 (23.1)
No UN (n = 111)	77.0 (7.7)	91.8 (15.9)	109.0 (13.7)	17.2 (9.9)	51.7 (21.8)
Right HPN and right HSN (n = 45)	75.1 (9.7)	81.1 (17.0)[a,b]	100.2 (17.1)[a,b]	19.1 (11.9)	64.0 (25.3)[a,b]
Left HPN and left HSN (n = 68)	73.7 (7.6)	81.8 (15.2)[a,b]	96.4 (18.1)[a,b]	14.6 (9.7)	56.9 (22.9)
Right HPN only (n = 13)	76.5 (5.1)	77.7 (14.9)[b]	100.5 (20.9)	22.8 (10.1)	67.1 (17.1)[b]
Left HPN only (n = 6)	73.5 (10.4)	96.3 (14.7)	115.3 (5.0)	19.0 (9.9)	54.7 (5.5)
Right HSN only (n = 27)	75.3 (8.4)	88.6 (20.8)	102.3 (19.1)	13.7 (8.4)	55.7 (28.0)
Left HSN only (n = 39)	75.2 (8.1)	97.2 (16.0)[b]	110.8 (12.5)[b]	13.6 (7.7)	43.5 (19.0)[b]
Any Right UN (n = 85)	75.4 (8.7)	82.9 (18.3)[a]	100.9 (18.1)[a]	17.9 (11.0)[b]	61.8 (25.3)[a,b]
Any Left UN (n = 113)	74.2 (7.9)[a]	87.9 (17.1)	102.4 (17.5)[a]	14.5 (9.1)[b]	52.2 (21.8)[b]
HSN only (n = 66)	75.2 (8.2)	93.7 (18.5)[b]	107.3 (16.0)[b]	13.6 (7.9)[b]	48.5 (23.7)[b]
HPN ONLY (n = 19)	75.5 (7.1)	83.6 (16.9)	105.2 (18.7)	21.6 (9.9)[b]	63.2 (15.5)
Both HSN and HPN (n = 113)	74.3 (8.5)	81.5 (15.9)[a,b]	97.9 (17.7)[a,b]	16.4 (10.8)	59.7 (24.0)[a,b]

For admission FIM, significant differences were identified between "right HPN and right HSN" and "left HSN only"; "left HPN and left HSN" with "left HSN only"; "right HPN only" and "left HSN only"; "HSN only" and "both HSN and HPN."

For discharge FIM, significant differences were identified between "right HPN and right HSN" and "left HSN only"; "left HPN and left HSN" with "left HSN only"; "HSN only" and "both HSN and HPN."

For change in FIM, significant differences were identified between "any right UN" and "any left UN"; "HSN only" and "HPN only"; "HSN only" and "both HSN and HPN."

For length of stay, significant differences were identified between "right HPN and right HSN" and "left HSN only; "right HPN only" and "left HSN only"; "any right UN" and "any left UN."

[a] Indicates that the value differs from the "no UN" group. Other between-impairment differences that attained statistical significance are identified with an "[b]" and listed above. All are based on the one-way analysis of variance and Tukey's post hoc testing.

HSN, hemispatial neglect; UN, unilateral neglect; HPN, hemipersonal neglect.

ated with significant differences in FIM gain as compared with subjects without UN (mean change of 17.2 points). When we examined subscales, it appeared that the significant differences were accounted for primarily by the subscales of self-care, mobility, and locomotion.

Table 3 also contains the results for LOS. Overall LOS was 55 ± 23 days. Those with right UN stayed the longest (mean 61.8 days), differing significantly from those with either left UN, or neither (52.2 and 51.7 days, respectively). LOS of those with right-sided HSN stayed an average of 9 days longer (P = 0.032). Those with right HPN stayed an average of 14.1 day longer ($P \leq 0.001$), compared with those without HPN, whereas those with left HPN stayed an average of 6.1 days longer than those without HPN; this did not attain statistical significance (P = 0.120). Those with both HSN and HPN had a longer mean LOS (59.4 days) than those with neither (51.7 days, P = 0.044).

Table 4 describes shoulder-hand problems and documented safety risk for subjects with UN. All 55 subjects with shoulder-hand problems also had ipsilateral hemiparesis (47.3% had right hemiparesis, and 52.7% had left hemiparesis), whereas another 251 with hemiparesis did not develop shoulder-hand problems. Of those with right hemiparesis 17.3% had shoulder hand problems, whereas 19.1% of those with left hemiparesis had shoulder-hand problems. Overall, those with right or left UN were more likely to demonstrate shoulder-hand problems as compared with those with neither (P = 0.003 for right *vs.* neither; P = 0.044 for left *vs.* neither), but numbers were similar between each other (P = 0.304). In those subjects with neither HPN nor HSN, only 9.9% had shoulder-hand problems. This is comparable with those with HSN only (9.1%, P = 1.00), but is significantly lower than those with HPN only (31.6%, P = 0.019), or both HPN and HSN (28.3%, P = 0.001). Those with both HPN and HSN were also at significantly greater risk to injure themselves ($P <$ 0.001). Of the subjects with shoulder-hand problems, 58.2% had both HPN and HSN, whereas similar percentages had HSN only, HPN only, or neither impairment. When considering side of impairment, those with right HPN had significantly more shoulder-hand problems when compared with the population without UN (P = 0.003). With respect to safety risk, those with right or left UN were at higher safety risk as compared with those without UN (P = 0.044 for right *vs.* neither, P = 0.009 for left *vs.* neither), but were again similar to each other (P = 0.663).

Overall, those with UN, right or left (27.1% and 23.9%, respectively), were less likely to be discharged home, as compared with those without UN (12.6%). There were no significant differences when comparing right and left UN with respect to DD. DD was significantly affected by the presence

TABLE 4 Number (%) discharged home, safety risk, and shoulder-hand complications in the presence of UN

Category	Discharge Destination Home	Safety Risk	Shoulder/Hand Complications
Overall (n = 309)	245 (79.3)	105 (34.0)	55 (17.8)
No UN (n = 111)	97 (87.4)	27 (24.3)	11 (9.9)
Right HPN and right HSN (n = 45)	29 (64.4)	20 (44.4)	12 (26.7)
Left HPN and left HSN (n = 68)	47 (69.1)	33 (48.5)	20 (29.4)
Right HPN only (n = 13)	11 (84.6)	2 (15.4)	6 (46.2)
Left HPN only (n = 6)	4 (66.7)	2 (33.3)	0 (0.0)
Right HSN only (n = 27)	22 (81.5)	10 (37.0)	4 (14.8)
Left HSN only (n = 39)	35 (89.7)	11 (28.2)	2 (5.1)
	P = 0.080	P = 0.146	P = 0.007
Any right UN (n = 85)	97 (87.4)	32 (37.6)	22 (25.9)
Any left UN (n = 113)	62 (76.1)	46 (40.7)	22 (19.5)
	P = 0.624	P = 0.769	P = 0.304
HSN only (n = 66)	57 (86.4)	21 (31.8)	6 (9.1)
HPN only (n = 19)	15 (78.9)	4 (21.1)	6 (31.6)
Both HSN and HPN (n = 113)	76 (67.3)	53 (46.9)	32 (28.3)
	P = 0.016	P = 0.031	P = 0.007

P values indicate whether there is a significant difference between any of the categories (excluding no UN), but the χ^2 tests do not further define the specific between-category differences.

HSN, hemispatial neglect; UN, unilateral neglect; HPN, hemipersonal neglect.

of HSN, with 25.7% of all with HSN being discharged to a destination other than home, as compared with only 13.8% of those without any HSN (P = 0.015). A total of 31.1% of all with HPN were more likely to be discharged elsewhere than home when compared with those without HPN (compared with 13.0%, $P < 0.001$). When mutually exclusive categories were created, those with both HPN and HSN were most likely to be discharged to a destination other than home (32.7%, P = 0.001), when compared with those with only HSN (13.6%), those with only HPN (21.1%), or those with neither (12.6%). DD did not differ significantly for subjects with right or left UN to either person or environment.

DISCUSSION

This article documents right and left UN of person and/or environment in a stroke rehabilitation population. Epidemiologic data should be taken in context, as this is a selected population, and as such, persons with severe UN and severe anosognosia who were not aware of their impairments were excluded.[29] Because UN was documented if at least two members of the team found some degree of UN in their assessment, many subjects may have had mild UN. Other articles have also documented the presence of neglect when detected by only a single test.[3]Different patterns of UN caused by right brain damage have previously been recognized by various authors (e.g., personal, extrapersonal, near, and far space).[36,37] In our study, we measured only attentional (observable), not representational deficits, which depend more upon self-report, and would be expected to be more difficult to detect in persons with aphasia. In our four subjects with bilateral neglect, lesions in deep structures were reported.

As would be expected, those with right UN were more likely to have aphasia, but there were some with left UN who demonstrated aphasia as well. Despite the presence of aphasia, we were nevertheless able to detect UN in these patients, through the use of gestures on the parts of assessors and subjects, and through observations of team members, including nurses, who are positioned to observe patients and can detect neglect of person as they conduct their activities of daily living, such as a patient neglecting to shave one side of his face, or neglect of the environment, such as a patient repeatedly bumping into doorways on one side of his body. Therefore, even in the presence of aphasia, it is often possible and worthwhile to assess and observe patients for either left or right UN after stroke.

Various imaging studies have been done to search for anatomical clues to UN.[38–41] Unfortunately, these have primarily looked at right-hemispheric strokes. Areas implicated include the right parietal cortex most commonly, right anterior cingulate cortex, basal ganglia, occipital or temporal lobe, posterior white matter fiber tracts, nucleus reticularis, thalamus, dorsolateral frontal lobe, mesencephalic reticular formation, insula, and ventral visual cortex.[14,38–42] Though our study did not employ imaging modalities to localize UN, most subjects in this real-world study had CT re-

ports available, implicating lesions in deep (thalami, internal capsule, basal ganglia), as well as cortical areas. Interestingly, most of the subjects with bilateral impairments had involvement of deep areas. Other reports have also implicated both deep and cortical areas in the anatomical localization of UN.[42–45] We recognize the limitations of our imaging results, as CT scans were primarily taken upon arrival to acute hospital; however, they are consistent with the theory of a neural network being involved in attention to personal and extrapersonal space.[23,43]Such an anatomic network has long been proposed in the literature, linking structures involved in UN and general attention.[23,46,47] Hemianopsia was common in those with HSN. Interestingly, some persons with left HPN also demonstrated right hemianopsia, with associated involvement of deep structures.

Different combinations of UN were found to exist in our study, including HPN only, HSN only, HPN and HSN, and bilateral neglect, the latter being infrequent in occurrence. Heilman et al.[48] conceived of UN as a heterogeneous condition, and some emphasize[17] the importance of distinguishing the types of UN present in individual patients. In our population, those with right UN had lower admission FIM scores, and stayed longer than those with left UN, achieving relatively higher FIM gains as a result. The reasons for the longer LOS possibly relate to the team extending treatment to achieve specific rehabilitation goals. The group with UN were actually somewhat younger than the group without, lending strength to the differences seen, because younger age has previously been observed to be a good prognostic factor with respect to stroke outcomes.[49] Although our study distinguished HPN from HSN, it did not document "allocentric" as compared with "egocentric" HSN, as defined in a recent publication.[12] Future studies documenting such details of UN may shed more light on the entity.

Our study documented some important characteristics of persons with UN. Patients may have UN of the person, environment, or both. Bilateral neglect can exist, though it is infrequent. Those with any UN at all functioned more poorly than those without UN, in keeping with findings of other studies looking at function and LOS in people with UN.[21] Those with UN of person, or HPN, do more poorly than those with HSN, and those with both HPN and HSN do even more poorly. These people demonstrated greater likelihood of having shoulder hand problems in the presence of hemiparesis, and of being discharged to institutions. Eighty percent of those with shoulder-hand problems had UN, suggesting that UN predisposes people to shoulder-hand problems, possibly due to a lack of attention to the limb itself, as in HPN, or combined HPN and HSN, which was the most frequent type of UN found in those with shoulder-hand problems. Those with HPN and HSN were more likely to be discharged to institutions than those with HPN alone.

Reports of vertical[50] and diagonal[51] attentional biases and neglect have also been reported in the literature. Our study did not specifically look for these directional impairments, though the assessment procedures could have detected them had they been a focus of study. Diagonal inattention, if present in our population, would be incorporated into primarily rightward or leftward inattention. Future studies of HSN after stroke could specifically look for HSN in all directions.

In our introduction, we indicated a myriad of assessments available to health professionals working with persons with stroke. The behavioral inattention test[52,53] is a commonly used battery to detect HSN; it has been validated in patients with acute stroke.[32] One functional test that has been proposed is the wheelchair collision test.[54] Another functional scale suggested is the Catherine Bergego Scale.[55] However, there is little agreement with respect to what to employ clinically for standardized assessments, and current literature is lacking in regards to methods of documenting severity of UN, particularly UN of person and far-extrapersonal space. Further assessment, validation, and development of such measures that are able to rate and classify the various types of UN may lead to better understanding of natural history, and effect of various management approaches.

In rehabilitation, the aim is to maximize function and safety. Our findings indicate increased safety risk in persons with right or left UN, as well as higher rates of shoulder-hand complications due to repeated injury of the side of UN, particularly in those with HPN. These persons generally require ongoing supervision, with implications for caregiver burden and DD. There are also implications for driving safety, and other activities.[56,57] It is therefore important to document the presence of these impairments.

Rehabilitation therapy focuses on restoring function. UN may improve with medications that improve general attention to tasks,[58] but such medications were not employed in our population. Nonpharmacological approaches to rehabilitation fall into three categories, including modification of environment, practise of functional tasks, and efforts to correct UN.[1] These approaches have primarily been based on studies of persons with left UN. They include observations that many subjects have problems with spatial working memory and perseveration.[59] Some experiments have shown that repeated visual scanning practice has led to improvements, and that background motion can

influence degree of neglect, suggesting a possible therapeutic approach.[60] Efforts to correct UN include sensory manipulations[61–66] such as caloric stimulation,[63,64] phasic alerting with warning sounds,[61] and the use of prisms.[62] Practically, in our experience, proprioceptive correction and prisms seem to be used regularly in stroke rehabilitation. Studies that enroll subjects with both right and left UN in determining effectiveness of treatments would be helpful.

There are a couple of reports that looked specifically at right HSN and potential rehabilitation strategies. One comes from the field of dyslexia research, indicating that direction of visual scanning influences severity of neglect dyslexia[67]; this can be incorporated in rehabilitation strategies, but needs more study for an understanding of the magnitude, generalization, and persistence of effect. Another report[68] acknowledges the difficulty of assessing attention in the presence of aphasia, and discusses an attention model of aphasia, whereby impairments in attention may cause aphasic symptoms. Strategies proposed for aphasic persons with right inattention include presenting visual information on the left side to minimize the inattention, and enhance the treatment of aphasia. Rehabilitation professionals could benefit from targeted studies of rehabilitative techniques for right-sided UN to guide informed management of right UN.

Bowen et al.[9] reported that UN occurs more frequently after right brain damage than left brain damage, but concluded that actual rates of occurrence could not be derived from their review. Our findings are in agreement with theirs, in that we found more subjects with left UN than right. However, our study was conducted in a rehabilitation unit, and may not represent true incidences after stroke. Although right-sided UN has been documented for at least a decade, most research studying mechanisms responsible for UN continues to focus on left-sided UN, possibly because left UN has been noted to be more persistent[42] and potential subjects may be easier to identify. Also, because it is easier to interview persons without aphasia in research exploring mechanisms of UN, research studies may exclude those with right UN to avoid challenges of communication. Our study indicates that clinical consequences of right and left UN are similar, and therefore, findings from studies involving only those with left UN may potentially be generalizable.

Those attempting to explain UN with models have sometimes chosen to completely ignore right-sided UN,[69] whereas others try to account for both hemispheres when considering models of UN.[70] However, right UN occurred with sufficient frequency that we should encourage more study of persons with right UN to better understand UN. Not until we begin to study right sided and other directional types of UN in greater depth, in addition to left UN, will we gain more complete understanding of the complex phenomenon of UN. Understanding mechanisms of UN may be helpful in developing more effective management of this difficult to treat condition.

CONCLUSION

In our study, we observed similar findings between those with right and left UN. We have presented further evidence that both left- and right-sided UN are not infrequent after stroke, have implications for function, safety, and DD, and that various subtypes of UN should be studied in more detail. Those with HPN and HSN demonstrate more shoulder-hand problems, longer lengths of stay in rehabilitation, and less likelihood of discharge home. Care should be taken to assess stroke patients for right or left UN, despite the presence of aphasia. Health professionals caring for patients with stroke should screen for UN for the purposes of planning rehabilitation management.

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