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Effects of acquired chronic brain injury on quality of life: A preliminary study in patients with a left or right-sided lesion

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Abstract

Objectives: *To test the hypothesis that quality of life (QOL) is made up of different components and each of these has different anatomic and demographic contributors.*

Design: *Questionnaire-based study*

Setting: *Center for Cognitive Neuroscience, University of Pennsylvania*

Participants: *52 people with chronic brain injury volunteered for the study. After excluding patients with severe communication deficits, bilateral lesions, and incomplete data, 42 patients with focal lesions were included in the final study: 22 patients with left hemisphere injury, LHI (9 females and 13 males; mean age 60.6 years (SD=11.2; Range: 36-83) mean chronicity 11.5 years (SD=4.2)) and 20 patients with right hemisphere injury, RHI (16 females and 4 males; mean age 62.7 years (SD= 12.8; Range: 31-79); mean chronicity 10.1 years (SD=4.3)).*

Interventions*: Not applicable.*

Main Outcome Measures: *We administered the RAND36-Item Health Survey (RAND-Version-1.0), Stroke Impact Scale (SIS-Version 3.0), Positive Affect and Negative Affect Scale (PANAS) and Distress Thermometer (DT) to measure QOL in LHI and RHI patients. Exploratory Factor Analysis (EFA) with principal component method reduced these measures to five factors, roughly categorized as— 1. Physical functioning, 2.General health, 3. Emotional health, 4. Social functioning, and 5. Cognitive functioning. Exploratory analyses attempted to relate these factor scores to demographic variables, neuroanatomical data, and neuropsychological measures.*

Results*: Physical functioning was the biggest contributor to reduced QOL, explaining 32.5%, of the variance. Older age, less education, and larger lesion size predicted poorer physical functioning (p < .001). Age also affected emotional health. (p=.019). Younger patients reported* *poorer emotional health than older patients. LHI patients reported less satisfaction with their cognitive functioning (p=.009) and RHI patients with their physical functioning (p=.06). Exploratory neuroanatomical analyses hinted at brain areas that may be associated with the perception of disability in each QOL component.*

Conclusions: *QOL is comprised of five components. Clinical and demographic factors appear to differentially impact these aspects of patients' perceived quality of life, providing hypotheses for further testing and suggesting potential relationships for therapeutic interventions to consider.*

Keywords: Quality of Life; Chronic Brain injury; Lesion laterality; Principal components

Abbreviations:

QOL- Quality of Life; LHI– Left Hemisphere Injury; RHI- Right Hemisphere Injury;

Quality-of-Life in Chronic Brain-Injury

Advances in medicine have allowed us to extend the length of life of people with neurological illnesses. Health-care professionals think beyond morbidity and mortality to include “well-being” as an end target of their treatment. Consequently, “well-year” is now recognized as a unit of health status[1]. Greater importance is being attached to patients’ subjective assessments of well-being and their satisfaction with treatment, as distinct from objective clinical measures of their health status. Quality of life (QOL) is important for evaluating efficacy and cost-utility of different treatment plans or interventions.

Recently, the mortality rates of patients with brain injury (e.g. stroke[2], TBI[3], and brain tumor[4]) have decreased. However, their health status is far from satisfactory[5]. According to Lai et al,[5] only 25 percent of stroke patients return to the level of everyday participation and physical functioning comparable to community-matched persons who have not had a stroke. Survivors of TBI[6] and brain tumors[7]also have significant functional and psychosocial impairments, limiting them in everyday activity and participation. Identifying the different factors that impact quality of life for patients with brain injury is necessary to guide focused rehabilitation strategies.

Laterality of lesion may be one such factor. Functional lateralization in human brain[8] means that patients with left hemisphere lesions have different deficits than patients with right hemisphere lesions. However, few studies have investigated the effect of laterality on the QOL of patients with brain injury and their results are not consistent[9]. Some reports support the idea that the right hemisphere is not as crucial as the left hemisphere for maintaining a good QOL[10–13]. Others assert that lesions in the right hemisphere cause significant reductions in QOL[14,15]. Several studies also report no differences based on the side of the lesion [16–19].

The inconsistent results of studies regarding the role of laterality in determining QOL may stem from differences in the tools used to measure QOL. Notably, the same group of patients performed differently on different scales of QOL[19]. Previous studies have also focused on particular etiologies rather than on the laterality of lesion, per se, making it unclear whether their results are tied to the particular etiology or reflect anatomy. In addition, most of these studies considered patients either undergoing treatment or patients who had just completed a treatment plan or in whom recovery was not complete[12,15,18]. Consequently, their reports on QOL were relatively unstable and likely to change with time and the acquisition of compensatory strategies. Only rare studies[13]addressed the long-term effects of stroke. Dhamoon et al[13] found a significant effect of lesion laterality on QOL. However, in this study[13]the patient, family member or health care provider rated the patient's QOL. Consequently, the study did not exclusively reflect the subjective experience or QOL perception of the patients themselves.

The present study is motivated to understand the neuroanatomic underpinnings of threats to QOL experienced by patients with focal brain injuries. At the coarsest level, we test the hypothesis that laterality of damage contributes differentially to QOL. However, for the reasons listed above, this hypothesis might be inadequately formulated if QOL cannot be reduced to a single construct. We also consider the possibility that laterality itself may be too coarse to assess brain-QOL relationships. Consequently, our study is a preliminary investigation to test the hypothesis that QOL is made up of different components, each of which is associated with different locations of brain injury. We also considered how demographic variables and neuropsychological impairments might affect QOL.

To test these hypotheses: 1) we selected patients with chronic focal lesions broadly, as a result of stroke, tumor resection, hemorrhage, or aneurysmal rupture; 2) we assessed quality of life in this group by administering a battery of relevant measures of QOL, two specific to QOL and two pertaining to mood; and 3) we used Exploratory Factor Analysis (EFA) with principal component method to distinguish different aspects of QOL and investigate the effects of lesion location on these components.

Methods

Participants: 52 patients enrolled in the Center for Cognitive Neuroscience Focal Lesion Database (FOLD) at the University of Pennsylvania, participated in the study. Database eligibility requirements include a diagnosis of a focal brain injury verifiable by MRI or CT scan, and absence of any other neurological disorder or injury, learning disorder, or psychiatric condition. Additional requirements of this study included absence of moderate or severe aphasia that would make understanding the survey instruments difficult. All database volunteers meeting these criteria and active during the study recruitment period (May 2013- August 2014) were invited to participate. All participants signed an informed consent approved by the Institutional Review Board of the University of Pennsylvania and were compensated financially for their time. After excluding patients with severe communication deficits (n=1), bilateral lesions (n=3), and incomplete data (n=6), 42 focal lesion patients with unilateral injury were included in the analyses: 22 patients with left hemisphere injury, LHI (9 females and 13 males; mean age 60.6

years(SD=11.2; Range:36-83); mean education 14.9 years (SD=2.7); mean lesion size 34.3 cc (SD=44.9); mean chronicity 11.5 years (SD=4.2)) and 20 patients with right hemisphere injury, RHI (16 females and 4 males; mean age 62.7 years (SD= 12.8; Range: 31-89); mean education 13.5 years (SD= 2.3); mean lesion size 45.0cc (SD= 53.2); mean chronicity 10.1 years (SD=4.3)). 64% of the brain-injured patients considered in this study had experienced a stroke. The other patients had focal injuries resulting from tumor resections, hemorrhages, and ruptured aneurysms.

There were no significant differences in age, education, lesion size and chronicity across LHI and RHI groups. The demographic and neurologic details of individual patients are presented in *Table 1*. Also included in *Table 1* are scores from four neuropsychological tests collected as part of their database participation, and reflective of their overall high level of cognitive function: Western Aphasia Battery (WAB[20]), American National Adult Reading Test (AMNART[21]), Philadelphia Brief Assessment of the Cognition (PBAC[22]), and Mini-Mental State Examination (MMSE[23]). All patients had their lesions mapped onto a standard brain template by a board-certified neurologist with the exception of two patients for whom films were not available. Data from these two patients were not included in the regression or exploratory lesion analyses.

QOL Test Materials: We administered the *RAND36-Item Health Survey (RAND*-Version-1.0)[24], perhaps the most widely used general assessment of health-related quality of life (HRQOL[25]), and the *Stroke Impact Scale (SIS-Version3.0)* [26], the most widely used disease-specific HRQOL tool for stroke patients. We also included two standard depression scales—*Positive Affect and Negative Affect Scale* (PANAS)[27]and *Distress Thermometer* (DT)[28]. Depression and hopelessness have been associated with a poorer present QOL[29], motivating our inclusion of the depression measures.

Procedure: Participants completed all four printed questionnaires in a single session either at the Hospital of the University of Pennsylvania or their homes. A researcher explained the instructions for each questionnaire before presenting it to the participants to complete.

Statistical analyses: A Factor Analysis (FA) using principal component method with a varimax (orthogonal) rotation was conducted on data obtained from 42 patients. We obtained 21 measures per patient: PANAS (2); DT (1); RAND subscales (8), RAND health change (1), SIS subscales (8), SIS stroke recovery (1). Because the sample size is smaller than typically obtained for factor analysis, we calculated a recommended measure in designs where the ratio of cases to variables is less than1:5– the Kaiser-Meyer Olkin (KMO) measure of sampling adequacy[30]. Examination of the KMO value indicated that the sample was factorable despite the small size (KMO=.7). Homogeneity of variance was confirmed by Bartlett's test (x^2 (210) = 511.6, p< .001). Communalities were above .5 for all items in the initial analysis. The diagonals of the anti-image correlation matrix were over .5 for all items except the positive and negative affects scores of the PANAS (PA_PANAS and NA_PANAS). We repeated the analysis after dropping PA_PANAS and NA_PANAS due to their low sampling adequacy. KMO of the new model was .7 and Bartlett's test was significant ((x^2 (171) = 452.9, p< .001). One item (SIS-Handicap) did not load above .5 on any component and was dropped from the analysis. The final factor analysis was conducted on 18 items. The KMO of the final model was .703 and Bartlett's test of sphericity was significant (x^2 (153) = 423.7, p<.001), again confirming that the data were factorable[30].

Communalities were above .5 for all items in the final analysis.

To anticipate the results, five factors were identified. A mixed-design ANOVA with group (LHI, RHI) as a between-subjects variable and the five QOL components as within-subjects variables was conducted to test for an interaction between group and QOL components. This analysis was followed by independent sample t-tests to determine if LHI and RHI groups differed across the five QOL components. A discriminant analysis was performed to test how accurately patients' perceived QOL in the five domains could discriminate the LHI and RHI groups.

Stepwise regression was conducted to test if demographic (age, education) and neurologic factors (lesion size, chronicity) predicted the QOL components. Last, exploratory lesion analyses were conducted to consider whether injury to specific brain areas are associated with lower scores on any of the QOL components. To better understand the observed patterns and the potential impact of other participant differences, we also considered the effect of neuropsychological test performance and gender in post-hoc analyses. Statistical analyses were done in SPSS Statistics[a] and lesion analyses were done in MRIcron[b].

Results

The final factor analysis was done on 18 items. We extracted five components with eigenvalues above 1.The five components explained 32.5%, 16.3%, 9.8%, 7.4%, and 6.2% of the variance, respectively. The cumulative percentage of variance explained by the five components was

72.2%. The rotated component matrix with the communalities of the items is given in *Table 2*. Based on inspection of the contributing individual items, we named the five factors: 1) ***Physical functioning***, 2) ***General health***, 3) ***Emotional health***, 4) ***Social functioning*** and 5) ***Cognitive functioning***. Four items had cross-loadings over 0.4 on other components, but they had primary loadings above 0.6. The factors emotional health and cognitive functioning had less than three item loadings but we retained them as separate factors because 1) emotional health and cognitive functioning are theoretically different concepts, and 2) Both RAND and SIS scales had fewer items measuring these two constructs.

A mixed ANOVA was conducted to assess the effect of laterality of lesion (LHI (n=22) vs. RHI (n=20)) on the five factors. There was no significant main effect of group (F(1, 40) = 0.96, p=.333) or factor scores (F(4, 160) =.006, p = 1). However, there was a significant Factor scores x Group interaction (F(4, 160) =2.54, p = .042; observed power =.7). Thus, the factor scores differed significantly in the LHI and the RHI groups (Figure1). An independent sample t-test revealed that cognitive functioning was perceived as more impaired by the LHI group (M= -.37, SD=1.1) than the RHI group (M= .40, SD=.63) (t(33.44)=2.78, p =.009, Cohen's *d*=0.86). RHI patients reported lower perceived physical functioning than LHI patients, a difference that approached significance (t(40) = -1.934, p = .06, Cohen's d =0.59). The results are summarized in *Table 3.* To further explore the locus of the perceived difference in cognitive functioning between LHI and RHI patients, we conducted a post-hoc comparison of the groups on four neuropsychological measures (MMSE, AMNART, WAB, PBAC). No significant differences were observed (*see Table 4*).

In the Discriminant analysis**,** the overall Chi-square test was significant (Wilks λ = .738, Chi-square = 11.38, df = 5, Canonical correlation = .51, p=.04). Cognitive functioning (r = .82) and physical functioning (r = -.6) were highly correlated with the discriminant function. Reclassification of cases based on the new canonical variable was successful.73.8% of the cases were correctly reclassified into their original categories. RHI and LHI groups were reclassified with 80% (16/20), and 68.2% (15/22) accuracy, respectively (see *Table 5*).

Given the uneven distribution of gender in the sample, we ran a post-hoc analysis to consider its potential impact on the results. A mixed ANOVA examining the effect of gender (male (n=17) versus female (n=25)) on the principal component scores did not yield any significant differences. There was no significant main effect of gender (F(1, 40) = .68, p= .416), no significant main effect of principal component scores (F(4, 160) = .06, p = .994), and no significant Gender x Principal component scores interaction (F(4,160) = 1.51, p = .201).

An exploratory stepwise regression analysis was conducted to predict the five factors. Education (β=, .567, t = 4.68, p <.001), lesion size (β= -.452, t =-3.59, p =.001), and age (β = -.307, t= -2.47,p = .019) predicted perceived physical functioning (F(3,39) =11.32, p < .001, R^2 =.485,Cohen's f^2=.94), indicating lesser education, larger lesion size, and older age were associated with worse perceived physical functioning after injury. Age (β = .369, t = 2.45, p = .019) also predicted perceived emotional health (F(1, 39) = 6.00, p = .019, R^2 = .136, Cohen's f^2 =.16), indicating that younger patients reported worse perceived emotional health. However, none of these factors predicted perceived general health, social functioning, or cognitive functioning. Chronicity did not predict any of the five principal components.

To identify the brain areas associated with each of these factors, we conducted exploratory lesion subtraction analyses. First, factor scores were rank ordered from the smallest to the highest. Then, for each factor, we subtracted lesions of patients within the upper quartile (i.e., top 25% on that factor) from the lesions of patients within the lower quartile (i.e., bottom 25% who scored low on that factor). In this way, we plotted the brain areas that corresponded to the perception of dissatisfaction in each of these QOL factors. The lesion coverage map and subtraction plots for all five factors are shown in *Figure 2* (a-f).

Discussion

Our study was motivated to understand the neuroanatomic and demographic variables that impair QOL in people with focal brain injury. We conducted a factor analysis to identify components of QOL experienced by people with chronic focal lesions. Our study was motivated by the hypothesis that QOL is not a unitary construct and that people's quality of life varies along different dimensions. A five-factor model explained 72.2% of variance in QOL. Physical functioning was the most important QOL component that explained the most variance, followed by general health, emotional health, social functioning, and cognitive functioning.

We did not observe any effect of gender on the QOL components. In contrasts to Drača[31], who reported that frequency of stroke in RH was significantly higher in men, we had few (4/20) male patients in the RHI group and a limited number of female patients in the LHI group (9/22). Larger sample size may be more sensitive for detecting potential differences in how men and women experience QOL following brain injury. If evident, determining neurological, sociological or demographic factors that might underly gender differences in QOL would be an important area for future research.

Although cognitive functioning explained the least variance, it distinguished the left and right hemisphere injured patients. We assessed the effect of laterality on each factor of QOL and ran exploratory analyses to identify the predictors and brain-behavior correlates of these factors. Here we discuss these findings and their implications.

Physical Functioning:

In our sample, QOL was affected most by patients' perceived level of physical disability. We also found that age, education and lesion size were predictors of perceived physical functioning. Consistent with Jun, Kim, Chun, & Moon[32], patients with higher education reported better perceived physical functioning. Without an objective measure of physical functioning, we cannot be certain of the relationship between socio-demographic variables and physical functioning, but the result clearly suggests that socio-demographic factors influence physical quality of life– which in turn may impact prognosis and rehabilitation. People with higher education may have access to better medical care or be more likely to follow up, thereby improving the odds of a better quality of life. Adequate counseling sessions for patients with lower education levels and subsidized follow-up treatment may help improve their physical functioning – the most important component of quality of life and, consequently, the one having a major impact on the QOL of caregivers as well [33].

Reports in the literature are inconsistent regarding the role of age and education in the health related QOL of brain-injured patients. While some studies find age[5,34,35] and education [36,37]crucial, others do not [19,38–40]. The effect of these factors may apply to specific QOL components, as found in our study. Global scores of QOL may be insensitive to the specificity of the effect.

Our exploratory lesion analyses indicated that lesions involving predominantly right motor cortex were associated with low perceived physical functioning. This observation is counter-intuitive as the left hemisphere controls the dominant right hand and most of our patients were right-handed. However, the kinds of motor-intentional deficits associated with right frontal damage might account for this observation[41]. Apart from lesions in the motor cortices, lesions in the bilateral-occipital lobe and the right superior temporal area were also associated with lower subjective ratings of physical functioning. One possibility is that lesions in these areas lead to difficulty in vision, exploration of objects, and processing of space-related information, all of which might restrict physical mobility and the activities of daily life[42].

General Health

Age, education, lesion size, and chronicity did not predict levels of general health. Lesion side (left, right) also did not have any effect on this component. The exploratory subtraction plot suggests that many right hemisphere areas are important to general health– superior parietal, middle occipital, precentral, angular gyrus, thalamus, caudate, putamen, and insula– as well as the bilateral anterior cingulate. We could speculate how damage to these areas affects self-care and general health. For example, the right superior parietal-occipital region is usually associated with neglect. Lesions in the thalamus are reported to disturb the total sensory motor relay, attenuate the body's arousal system, disrupt emotion processing, and cause mood disorders. Acute post-stroke depression is often associated with thalamic lesion [43]. Thalamic lesion can also cause pain or Dejerine–Roussy syndrome[44]. Lesions in the caudate[45]and anterior cingulum[46]may cause emotional disturbances. Lesions in the insula can affect awareness [47]. Future prospective studies could target the occurrence of these neurobehavioral symptoms with subjective reports of the quality of general health that patients with injuries in these areas experience.

Emotional Health

Only age significantly predicted emotional health in the present study. Older patients reported better emotional health than younger patients. This finding is consistent with previous studies observing greater emotional well-being with age[48]. Others report that older adults move out of a negative emotional state faster than younger adults and are less likely to experience negative affect consistently[49]. Younger people may be burdened by liabilities like dependents to care for and these stresses may contribute to their low emotional health[50]. Younger patients may need counseling to boost their emotional well-being and vocational rehabilitation for successful return to work[51]and to alleviate their anxiety over financial insecurities. Most areas implicated in our exploratory anatomic analysis–left middle orbito-frontal cortex, left frontal areas, right frontal areas, bilateral insula, right caudate, right putamen, right thalamus, bilateral temporal cortex, right parietal cortex – are associated with the neural bases of emotion processing[52].

Social Functioning

Age, education, lesion size, side, and chronicity did not predict social functioning. However, the subtraction plot included areas implicated in Theory of Mind (right angular gyrus, right medial frontal areas, and left temporal pole)[53], areas important for action observation (left inferior frontal gyrus, right inferior parietal lobule)[53,54], and subcortical areas involved in social cognition (right cingulum and left caudate)[55,56]. Theory of Mind (ToM) refers to the ability to understand and interpret another person's beliefs, emotions, and intentions. ToM requires both cognitive and emotional perspective-taking and is necessary for social functioning[57]. Similarly, understanding the intentions of others while observing their actions is a fundamental aspect of social behavior[58].

Cognitive functioning

Age, education, lesion size, and chronicity did not predict the level of perceived cognitive functioning. However, patients with left hemisphere injury reported significantly lower perceived cognitive functioning than patients with right hemisphere injury. This subjective report was obtained despite LHI patients not exhibiting significant differences from RHI patients on standard neuropsychological measures of language, memory, visuospatial abilities, or executive function. One reason for this discrepancy between subjective and objective reports could be that while patients of both groups were able to answer with comparable accuracy, LHI patients may have had to exert greater cognitive effort. The lack of self-awareness generally associated with right hemisphere lesions is another possible explanation for this difference. Lunven et al [19]observed that right-brain-injury patients, but not left-brain-injury patients, underestimated their difficulties when their scores were compared to scores provided by caregivers. Our subtraction analysis reveals that lesions primarily impacting language and memory areas of the brain (e.g. bilateral angular gyrus and left inferior frontal cortex (pars triangularis), middle frontal, middle temporal gyrus, insula, putamen, and caudate) were associated with subjective assessments of lower cognitive functioning. Although limited by reverse inference, this pattern is more consistent with a cognitive effort than an awareness-related interpretation of the laterality effect. Patient perception of their abilities and disabilities appears more fine-grained than our rigorously designed clinical tests.

Limitations

This study was conducted on a relatively small sample consisting of 42 patients, making our behavioral findings preliminary and limiting our power to conduct detailed brain-behavior analyses. We consider the results of our lesion analyses to be hypothesis-generating. Future studies are needed to verify these brain-behavior correlations. Although our sample size was smaller than typical of principal component analyses, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity confirmed that the data set can be used for factor analysis. We found a large effect size (Cohen's d=.86) for the difference in perception of cognitive functioning across the LHI and RHI groups. The effect size of the regression analysis for QOL component 1 (physical functioning) was also large (Cohen's f^2=.94). The regression analysis for QOL component 3 (emotional health) had a small but non-trivial effect size (Cohen's f^2=.16). Thus, the effect size measures reassure that the study reports significant and relevant information on patients with brain injury despite having a low sample size.

The varied etiologies of the patient population are both a strength and weakness of the design. Post-injury reorganization may differ between stroke and tumor patients, and different risk profiles and medications may contribute differently to their post-injury recovery and cognitive profiles. However, the inclusion of aneurysm and tumor patients allows us to sample the brain more broadly, as stroke lesions are limited by the vascular distribution. Limiting our analysis to stroke patients would have weakened our statistical power unnecessarily given that we do not have clear reasons to predict differences between stroke and the other patient subtypes.

We consider the results of our PCA and lesion analyses to provide preliminary support for our hypotheses: that QOL is a multi-faceted construct, and injury to different brain areas can differentially impact these facets. In order to strategically target therapeutic interventions based on injury site, and to establish the possible impact of lesion cause, confirmation with a larger sample size and more even distribution of etiologies will be an important next step.

Conclusions

Since 1980, fatalities from heart disease and stroke have decreased by more than half [59] and the cancer death rate has dropped by 26% from 1991 to 2005[60]. These advances raise the importance of assessing quality of life associated with these conditions following rehabilitation. We found that perception of physical disability had the greatest impact on patients' QOL. Education, lesion size, and age predicted perceived physical functioning. Older patients were more satisfied with their emotional health than younger patients. Patients with left hemisphere lesions were less satisfied with their cognitive functioning and had lesions in the areas of the brain typically implicated in language and memory functions. In summary, our study provides preliminary support for our hypothesis that different factors contribute to different components of the quality of life experienced by patients with neurological injury. Our exploratory lesion analyses also generated a rich set of hypotheses for future testing. Closer attention to these domains can help guide rehabilitation and restorative efforts in this growing population of people.

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List of suppliers

[a]IBM Corp. Released. IBM SPSS Statistics version 25.0. *2017*. 2017.
[b]MRIcron software (http://www.mricro.com/mricron).

List of figures:

Figure1. Mean and Standard deviations of the five QOL factors in patients with RHI and LHI *$p<.05$.

*Figure2 (a-f).*The colored scale represents the number of lesions for each pixel. (a)Lesion coverage map; (b-f) Subtraction plots (left side represents the right hemisphere and right side represents the left hemisphere)

*Table 1.*Demographic, neurologic and neuropsychological details of LHI and RHI patients

ID	Gender	Age	Edu (years)	Lesion Side	Location	Lesion size (CC)	Cause	Chronicity (years)	AQ	AMN/ART (Revised, 2/10)	PBAC-Memory (27)	PBAC-Visuo-Spatial (18)	PBAC-Language (12)	PBAC-Executive (26)	PBAC-Behavior (24)	MMSE (30)
85	F	65	15	Left	Ins	13.1	Stroke	16.9	98.8	122.0	18	18	11	19.5	24	29
107	M	72	16	Left	FP	33.2	Stroke	16.2	N/A	103.0	N/A	N/A	N/A	N/A	N/A	N/A
141	F	54	16	Left	Ins	21.6	Stroke	14.0	98.8	113.0	N/A	N/A	N/A	N/A	N/A	N/A
215	M	64	14	Left	F	17.4	Stroke	14.5	94.4	106.0	18	17	11	18.5	24	29
236	M	68	19	Left	FP	156.0	Stroke	20.7	90.8	100.0	17.5	17	8.5	9.5	24	29
244	M	60	15	Left	T+Cer+Pons	47.2	Stroke	13.9	98.4	109.0	N/A	N/A	12	18.5	24	27
318	F	63	12	Left	BG	20.7	Stroke	13.4	99	112.0	21.5	18	12	19	24	29
342	F	60	12	Left	O+T+Cs	42.1	Stroke	13.0	93.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A
343	M	58	14	Left	T+Cer	20.1	Stroke	12.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
363	M	76	16	Left	F	16.8	Stroke	11.7	91.4	104.6	14	18	9	15.5	24	25
384	M	73	12	Left	F	11.3	Hemorrhage	12.3	93.1	102.4	14	13	10	19.5	24	22
428	M	58	12	Left	ACC+F+CC	3.6	Stroke	12.2	95.5	109.4	15.5	12	10.5	17.5	24	30
493	M	70	14	Left	F	22.4	Aneurysm+Hemorrhage	10.3	92.1	104.0	10	18	10.5	15.5	24	24.5
529	F	68	12	Left	F	9.0	Stroke +Aneurysm	10.4	94.9	95.0	13	13	8	17.5	23	26
534	F	63	16	Left	F	N/A	Aneurysm	10.1	N/A	120.0	N/A	N/A	N/A	N/A	N/A	N/A
541	M	49	19	Left	F	18.8	Tumour resection	10.4	N/A	122.0	21.5	18	11	22	24	25
565	M	56	12	Left	F	14.5	Aneurysm+Hemorrhage	10.6	N/A	121.0	N/A	N/A	N/A	N/A	N/A	N/A
642	M	79	12	Left	P	8.0	Stroke	11.4	96.8	N/A	16	18	11	19	24	25
755	F	50	16	Left	Cer	N/A	Stroke	3.9	N/A	120.0	20	18	12	21.5	24	30
775	M	45	20	Left	F	27.3	Aneurysm	6.1	99.2	110.4	13	16	11	20.5	24	29
792	F	31	14	Left	F	167.3	Tumour resection	2.2	99.6	106.2	14.5	14	10	17	24	27
795	F	52	20	Left	F	15.2	Tumour resection	6.6	96.0	124.8	21.5	18	12	20	24	30
83	M	72	12	Right	FTP	8.0	Stroke	16.6	99.8	114.0	17	16	12	23.5	24	29
87	F	74	15	Right	F	10.5	Stroke	16.7	99.1	113.0	23.5	17	10	20	24	28

112	F	50	16	Right	O+Th	4.7	Stroke	16.6	100	119.0	22	18	12	23	24	29
264	F	63	12	Right	F	45.3	Hemorrhage	14.5	N/A	116.0	N/A	N/A	N/A	N/A	N/A	N/A
444	F	82	12	Right	TP	15.5	Stroke	11.5	95.5	99.0	15	13	11.5	21.5	24	25
474	F	53	11	Right	P	22.2	Stroke	10.8	95.1	89.0	21	12	12	17.5	24	28
552	F	64	13	Right	F	4.1	Aneurysm	13.7	99.4	106.0	18.5	18	12	22	24	30
569	F	75	12	Right	FT+BG	37.4	Stroke	8.6	99.8	104.0	23	17	11	23	24	30
577	F	83	11	Right	Cer	4.2	Stroke	15.3	85.3	88.96	8.5	13	8	13	23	26
592	F	46	12	Right	FP	130.6	Stroke	11.8	97.8	110.0	19	14	12	19	22	29
593	F	52	12	Right	FTP+ BG+Cau	170.1	Stroke	7.3	100	95.4	10.5	10	10	15.5	24	27
612	M	52	13	Right	Cer+Pons	27.8	Stroke	8.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
640	F	72	18	Right	TP	64.6	Stroke	6.5	96.8	126.0	N/A	N/A	N/A	N/A	N/A	N/A
657	M	77	18	Right	PO	33.6	Stroke	5.6	99.2	126.2	21	18	12	21.5	24	28
665	F	54	14	Right	P	30.1	Tumour resection	4.7	N/A	110.0	22	18	12	22	24	30
694	F	36	12	Right	FP+BG+ Cau+Ins	46.5	Stroke	10.0	96.2	106.0	15.5	18	9	20.5	24	27
716	M	71	17	Right	F	182.1	Stroke +Aneurysm	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
738	F	62	16	Right	Cer	32.2	Stroke	5.5	98.4	125.4	26	18	11.5	21	24	30
785	F	60	12	Right	F	7.7	Tumour resection	7.9	99.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
797	F	56	12	Right	T +brainstem	22.8	Tumour resection	4.6	N/A	114.7	16.5	14	10	20	24	30

Key: Edu – Education, M – Male, I – Insula; F – Female (Gender), F – Frontal (Location); P – Parietal; T – Temporal; Cer – Cerebellum; BG – Basal Ganglia; O–Occipital; Cs – Centrum Semiovale; ACC – Anterior cingulate cortex; CC – Cingulate Cortex; Th – Thalamus; Cau – Caudate; N/A– Not available; WAB – Western Aphasia Battery; AMNART – The American National Adult Reading Test; PBAC – The Philadelphia Brief Assessment of Cognition; MMSE – Mini-Mental State Examination

Table 2. Rotated component matrix with communalities of the items

Items	1. Physical Functioning	2. General Health	3. Emotional Health	4. Social Functioning	5. Cognitive Functioning	Communalities
SIS Strength	0.92					0.9
RAND PF	0.863					0.834
SIS Mobility	0.802					0.82
SIS ADL+IADL	0.767					0.827
SIS Hand function	0.635		0.465			0.722
SIS Stroke Recovery	0.575				0.424	0.716
Distress		-0.716				0.733
RAND General Health		0.706				0.681
RAND Health Change		0.675				0.544
RAND Energy Fatigue		0.638	0.421			0.73
SIS Emotion			0.763			0.634
RAND EWB			0.625			0.522
RAND Pain				0.701		0.791
RAND RLPF				0.681		0.7
RAND RLEP				0.66	0.42	0.781
RAND SF			0.474	0.639		0.642
SIS COMM					0.809	0.727
SIS Memory					0.705	0.659

Key: PF – Physical Functioning; ADL – Activities of Daily Living; IADL – Instrumental Activities of Daily Living; EWB – Emotional Wellbeing; RLPF – Role Limits Physical Functioning; RLEP – Role Limits Emotional Problems; SF – Social Functioning; COMM – Communication

Table3. Result of Independent Sample t-test of the five PCA components

Components	Group	N	Mean	Std. Deviation	t	df	p-value
1-Physical Functioning	RHI	20	-0.3	1.02			
	LHI	22	0.28	0.92	-1.934	40	0.06
2-General Health	RHI	20	0.05	1.01			
	LHI	22	-0.05	1.01	0.304	40	0.763
3-Emotional Health	RHI	20	0.11	0.98			
	LHI	22	-0.1	1.03	0.681	40	0.5
4-Social Functioning	RHI	20	0.09	1.03			
	LHI	22	-0.08	0.99	0.543	40	0.59
5-Cognitive Functioning	RHI	20	0.41	0.63			
	LHI	22	-0.37	1.14	2.781	33.438	0.009

Key: RHI – Right Hemisphere Injury; LHI – Left Hemisphere Injury

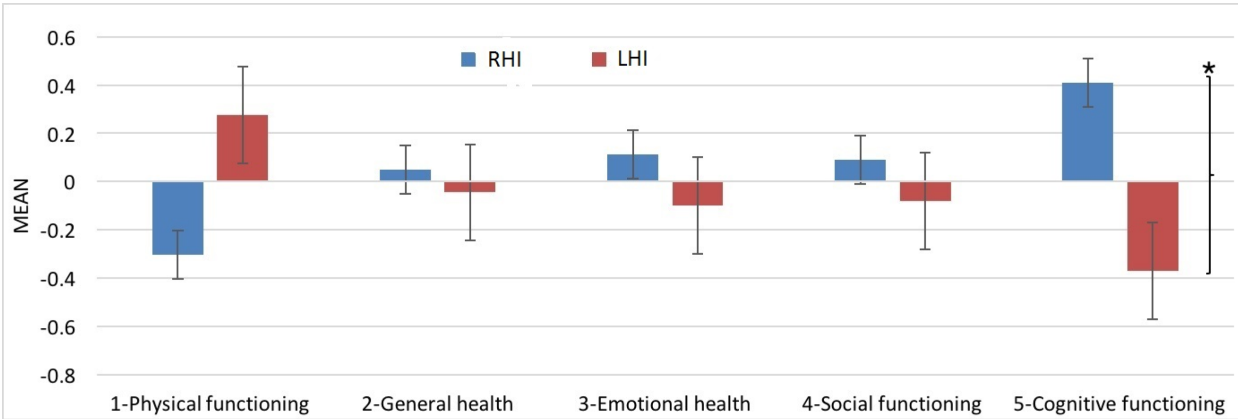
Table 4. Comparisonof Standard NeuropsychologicalTests in LHI and RHI patients

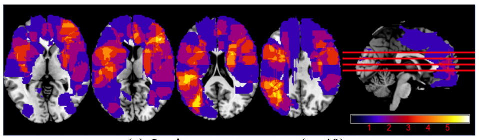
Cognitive Scales	Patient Group	N	Mean	Std. Deviation	t-value	df	P-value
WAB-AQ	RHI	15	97.43	3.74			
	LHI	16	95.76	3.01	1.373	29	0.18
AMNART	RHI	17	109.57	11.73			
	LHI	19	110.78	8.69	-0.354	34	0.725
PBAC-MEMORY	RHI	15	18.6	4.86			
	LHI	15	16.53	3.56	1.33	28	0.194
PBAC-VISUOSPATIAL	RHI	15	15.6	2.69			
	LHI	15	16.4	2.23	-0.886	28	0.383
PBAC-LANGUAGE	RHI	15	11	1.3			
	LHI	16	10.59	1.24	0.892	29	0.38
PBAC-EXECUTIVE	RHI	15	20.2	2.93			
	LHI	16	18.16	2.96	1.932	29	0.063
PBAC-BEHAVIOUR	RHI	15	23.8	0.56			
	LHI	16	23.94	0.25	-0.892	29	0.38
MMSE	RHI	15	28.4	1.59			
	LHI	16	27.28	2.45	1.496	29	0.145

Key: WAB – Western Aphasia Battery; AQ – Aphasia Quotient; AMNART – The American National Adult Reading Test; PBAC – The Philadelphia Brief Assessment of Cognition; MMSE – Mini-Mental State Examination

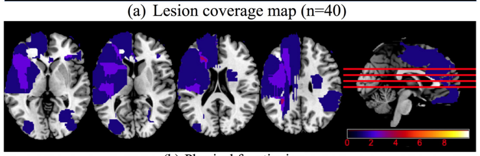
Table 5. Result of Discriminant Analysis

Standardized Canonical Discriminant Function Coefficients	
	Function 1
Physicalfunctioning	-.636
Generalhealth	.109
Emotionalhealth	.242
Socialfunctioning	.194
Cognitivefunctioning	.824
Functions at Group Centroids	
RHI	.609
LHI	-.554

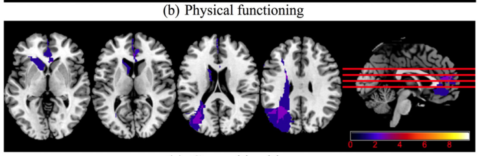

0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
MEAN
RHI
LHI
*
1-Physical functioning
2-General health
3-Emotional health
4-Social functioning
5-Cognitive functioning



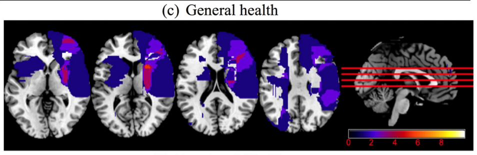
(a) Lesion coverage map (n=40)



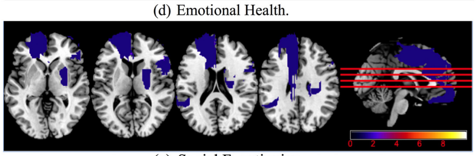
(b) Physical functioning



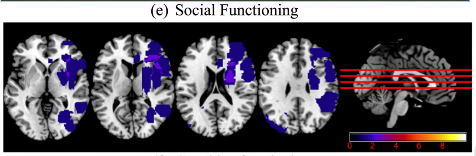
(c) General health



(d) Emotional Health.



(e) Social Functioning



(f) Cognitive functioning

HIGHLIGHTS

- Quality of life comprises physical, emotional, cognitive, social, & general health
- Left hemisphere injured patients are less satisfied with their cognitive function
- Right hemisphere patients are less satisfied with their physical function
- Age, education, and lesion size influence perceived quality of life after injury
- Lesion location may mediate which aspects of quality of life are adversely impacted