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Research Paper

Language Deficits in Non-Dominant Hemisphere Stroke Patients

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ABSTRACT:

BACKGROUND:

Despite the long history of research favoring the left hemisphere is dominant for language processing in most right-handed subjects. There is accumulating evidence that the right hemisphere contributes to language.

OBJECTIVE:

To evaluate language deficits in right hemisphere stroke survivors so they will have the opportunity to be tested for deficits and offered compensatory strategies.

PATIENT AND METHODS:

case control study, right-handed patients from 3 hospitals and a physiotherapy Centre in Iraq, aged (38-75 years), each had either right or left hemispheric stroke, patients with bilateral hemispheric stroke and who are not sufficiently clinically stable to be approached were excluded, and a control group of neurologically healthy participant. we used the quick aphasia test for both patients and control groups, data collected between April 2022 and February 2023.

RESULTS:

We included 40 patients, 20 had right hemispheric stroke and 20 had left hemispheric stroke, and 20 controls who were neurologically healthy. The mean age for patients was 58.2 years, aphasia was found in 30% of right hemispheric stroke patients and 35 % of left hemispheric stroke patients. Sentence comprehension was the most often impaired task for both left hemispheric stroke patients with mean score 7.19(SD = 2.36) and right hemispheric stroke patients with mean score of 8.07 (SD = 1.64). the difference in mean for word comprehension between right hemispheric stroke patients 9.58 (SD = 0.83) and control group (10 SD 0) was statistically significant with p value (0.03). grammatical construction was impaired more for the left hemispheric stroke patients with mean score 8.95(SD = 1.49) than the right hemispheric stroke patients with mean score 9.41 (SD = 0.6).

CONCLUSION:

Right hemisphere is involved in language which can be affected by stroke so it is vital to be looked for, so adaptations can be offered for those patients for a better life.

KEY WORDS: aphasia, language, non-dominant, right hemisphere, stroke.

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INTRODUCTION:

The anatomical asymmetry of the human brain hemispheres is well accepted. The exact nature of the functional asymmetry is still up for question after centuries of discussion. The "minor" right hemisphere (RH) is defined as non-dominant, nonverbal, visuospatial, holistic, and creative, in contrast to the dominant, verbal, analytical, and intelligent characteristics of the "major" left hemisphere (LH)(1).

The verbal/nonverbal explanation of LH/RH specialization is by far the most often used of all the dichotomies proposed to characterize brain lateralization of function. Undoubtedly, the LH is the better language processor; nevertheless, an increasing number of studies has shown the "nonverbal" RH to have considerable language skills. So, in this research we are investigating the extent to which the right hemisphere contributes to language and in which language subsets. We are doing this by using a faster and simpler test that can be used even in acute stroke settings and then comparing our findings with earlier research on this topic.

An increasing amount of research is showing that the right hemisphere is not nonverbal, but rather has strong language processing abilities. The right hemisphere is heavily involved in a variety of processes, including prelexical, lexical, and postlexical components of visual word recognition and prosodic and paralinguistic aspects of speech production, reception, and interpretation.[2]

There is growing evidence that the right hemisphere (RH) contributes to (1) language function in neurologically normal individuals[3,4], and (2) language recovery after (a) left-hemisphere brain damage[5,6,7,8,9] or (b) disruption of left-hemisphere processing[10,11]. This contrasts with a long history of research supporting the view that the left hemisphere is dominant for language processing in most right-handed subjects.

The RH challenges the validity of a rigid verbal/nonverbal explanation of hemisphere function because to its high receptive language ability and comprehension skill, as well as its critical role in the prosodic, pragmatic, and paralinguistic components of spoken language[12].

Patients with right hemisphere strokes experienced a greater degree of difficulty understanding more complicated semantically reversible statements (such as "The singer hits the soldier" and "The shoe under the pencil is blue") when the most common subject-verb-object relationship was flipped[13].

These kinds of complex statements can be extremely difficult for patients to understand, which could have major real-world effects. An individual who has suffered from a stroke with right hemispheric damage may interpret a statement such as "The pill under the bottle is for you" incorrectly, believing it to mean that he should take the entire bottle.

Patients with impaired RH show a range of pragmatic difficulties because an intact RH preserves activation of multiple plausible interpretations. These errors include taking idioms, proverbs, and metaphors too literally. For instance, the popular metaphor "I cried my eyes out" conjures up a rather graphic picture[14]. Parallel to this, people with RH damage also struggle to comprehend and interpret sarcasm[15].

Functional imaging research is beginning to show that both hemispheres are engaged in the production of expressive language, unlike previous theories that suggested articulation generation was exclusively a LH function[16,17,18]. The RH supports the LH by regulating the prosodic and non-propositional aspects of expressive language, even though the LH is primarily in charge of programming the motor commands required for speech production. As expected, Larsen et al. (1979)[19] verify that during verbal recitation: ". [none of our research has yet found any striking difference in cortical activation between right and left hemispheres during complex lateralization processes which involve speech. Our conclusion so far is that in [the] normal brain both hemispheres are highly active,".

According to Joanette and Goulet's (1994)[20] research, more than half of patients suffering from RH damage have issues with verbal communication. Even though it is critical that these individuals be correctly identified and referred to speech and language therapists, studies show that communicative and pragmatic deficits are not often diagnosed. The medical records of 122 individuals with RH damage were evaluated by Lehman Blake, Duffy, Tompkins, and Myers (2003)[21]. They discovered that the diagnosis of defects varied depending on the practitioner's background. Naturally, professionals in the fields of speech-language pathology and neurology, neuropsychology, and occupational therapy were more likely to diagnose pragmatic and communicative disorders, while attentional, visuoperceptual, and learning disorders were more often diagnosed by occupational therapists.

Moreover, teaching stroke survivors and their carriers about these comprehension deficiencies can help them in using compensatory techniques. In order to increase communication, carriers and family members should employ techniques like clearly expressing the emotions they are experiencing and using simpler language instead of more complex ones. The work of Garjardo Vidal and colleagues lays the groundwork for upcoming investigations into the particular executive processes that underpin language comprehension, as well as for the possible creation of therapies that specifically address these deficiencies[13].

PATIENTS AND METHODS:

Study design and setting:

In this case control study, patients were recruited from 3 hospitals (Baghdad hospital in medical city, Neuroscience hospital and Al Yarmouk hospital) and a physiotherapy center in Baghdad / Iraq and a control group who were neurologically healthy who were mostly the patients' relatives coming from similar educational background between April 2022 and February 2023.

Participants:

Inclusion criteria: Right-handed 40 patients, 20 patients with left hemispheric stroke and 20 with right hemispheric stroke proved clinically and by brain image who were sufficiently clinically stable to be approached, can be aroused, oriented to time, place and person and who can keep attentive for at least 15 to 20 minutes; and right-handed 20 controls who were neurologically healthy and were mostly relatives to the patients and coming nearly from similar educational background.

Exclusion criteria: Any patient who is not sufficiently clinically stable to be approached, can't be aroused, can't follow commands who are not fit for the quick aphasia test, any patient with bilateral hemispheric stroke were excluded.

Patients who previously suffered from dementia, or impaired cognitive and impaired language functions at baseline for any other reason and who had major psychiatric disorders.

Data collection:

The study size arrived at by selecting inpatients who suffered from acute stroke who can keep attentive for at least 15 to 20 minutes which was a little bit of limitation also patients with chronic stroke who visited the physiotherapy center.

For each of the participants of (RH stroke patients, LH stroke patients and neurologically healthy group) the demographic data and risk factors for vascular events including hypertension, diabetes and smoking were collected.

Then each of the participants were tested using quick aphasia test questionnaire with its translation adapted into Arabic version[22,23] https://aphasialab.org/qab.

This test consists of eight subtests, each containing various items that assess different language areas, have varying levels of difficulty, and are evaluated using a graded system to enhance the informative value of each item. These subtests yield eight summary measures, forming a comprehensive profile of language abilities that measure strengths and weaknesses in key language domains.

First, each participant is tested for the 8 subsets which are: level of consciousness, connected speech, word comprehension, sentence comprehension, picture naming, repetition, reading aloud, motor speech.

Each subtest contains 5 to 12 items, each of which is scored on a 5-point scale running from 0 to 4. please check the website link https://aphasialab.org/qab for various versions of quick aphasia battery according to your native language.

Second after calculating each subset, eight summary measures are formed from these subsets the eight summaries are: (1) Word comprehension; (2) Sentence comprehension; (3) Word finding (4) Grammatical construction; (5) Speech motor programming; (6) Repetition; (7) Reading; and (8) QAB overall. Table (1)

The range of each summary measure is from 0 (impaired) to 10 (unimpaired). Table 1 illustrates the calculation of each summary measure from the eight subsets. All summary measures are on a scale of 10 and are derived by dividing the score described by its denominator, then multiplying by 10 or the appropriate percentage of 10 as indicated. calculation of summary measures was done for each person which consist of the following table.

Table 1: Summary measures of quick aphasia test.

Summary measures	Definition	
Word comprehension	Word comprehension total, corrected for chance by subtracting 8 and clipping at 0; denominator is now 24	
Sentence comprehension	Sentence comprehension total, corrected for chance by subtracting 24 and clipping at 0; denominator is now 24	
Word finding	60%	Picture naming total
	20%	Connected speech: Anomia
	20%	Average of Connected speech: Empty speech, Semantic paraphasias, and Phonemic paraphasias, but capped so as not to exceed Anomia
Grammatical construction	40%	Connected speech: Agrammatism
	20%	Connected speech: Reduced length and complexity
	20%	Connected speech: Paragrammatism, but capped so as not to exceed Agrammatism
	20%	Average of sentence items from repetition and reading subtests
Speech motor Programming	Motor speech: Apraxia of speech	
Repetition	Repetition total	
Reading	Reading aloud total	
QAB overall	18%	Word comprehension summary measure
	18%	Sentence comprehension summary measure
	14%	Word finding summary measure
	14%	Grammatical construction summary measure
	8%	Speech motor programming summary measure
	8%	Repetition summary measure
	8%	Reading summary measure
	8%	Connected speech: Overall communication impairment
	2%	Connected speech: Reduced words per minute
	2%	Connected speech: Self-correction

Statistical analysis:

Calculation of the summery measures for each participant was done then the mean of each summery measure was calculated in each group (RH stroke patients' group, LH stroke patients' group and neurologically healthy' group) then the difference in mean of each summary measure between the LH stroke patients' group and the healthy group , between the RH stroke patients' group and healthy group and between the RH and LH stroke patient' groups was calculated and significance of each difference was tested with a p value less than 0.05 statistically significant, We Used SPSS for statistics.

T test: two samples assuming an equal variance.

RESULTS:

40 stroke patients (20 with dominant hemisphere stroke and 20 with non-dominant hemisphere stroke) and 20 neurologically healthy participants were included in this study mean of age for patients 58.2 y (SD =0.23).

The demographic data and risk factors for the patient groups were as follows: Among the patients, there were 23 females and 17 males, with 6 having a negative past medical history, 14 being diabetic (DM), 4 being hypertensive (HTN), and 16 having both DM and HTN. Additionally, 12 patients were smokers, and 7 had experienced stroke more than 3 months prior, while the rest experienced stroke within one week of the test.

In the dominant hemisphere (LH) stroke patients' group, the mean age was 56.85 years (range: 35-73) with a standard deviation (SD) of 9.84. There were 12 females and 8 males, with 7 smokers and 13 non-smokers. Six had chronic stroke, while the remaining patients had stroke within one week of the test. Regarding chronic diseases, 3 had no past medical history, 6 had DM, 1 had HTN, and 10 had both DM and HTN.

In the non-dominant hemisphere (RH) stroke patients' group, the mean age was 59.55 years (range: 42-75) with an SD of 8.35. There were 11 females and 9 males, with 5 smokers and 15 non-smokers. One had chronic stroke, while the others had stroke within one week of the test. Regarding chronic diseases, 3 had no past medical history, 8 had DM, 3 had HTN, and 6 had both DM and HTN.

For the healthy controls group, the mean age was 62.5 years (range: 55-70). There were 9 females and 11 males, with 7 smokers and 13 non-smokers. Nine had no past medical history, 8 had DM, and 3 had HTN.

Table 2: Demographics data and risks factor.

	All patients		**Dominant hemisphere Stroke (n=20)**		**Non dominant hemisphere stroke (n=20)**		**Neurologically healthy control (n=20)**
Age	Mean 58.2	SD 0.23	Mean 56.85	SD 9.84	Mean 59.55	SD 8.35	Mean 62.95
gender							
Male	17 (42.5%)		8 (40 %)		9 (45 %)		11(55%)
Female	23 (57.5 %)		12 (60%)		11 (55%)		9 (45%)
Risk factors							
Smoking	12 (40%)		7 (35%)		5 (25%)		7(35%)
DM	14 (35%)		6 (30%)		8 (40%)		8 (40%)
HTN	4 (10%)		1 (5%)		3 (15%)		3 (15%)
DM&HT	16 (40%)		10 (50%)		6 (30%)		0
Duration							
Acute	33 (82.5%)		14 (70%)		19 (95%)		
Chronic	7 (17.5%)		6(30%)		1 (5%)		

After testing each group with the quick aphasia test the mean values and SD of each language summary measure for each group was measured as follows:

Table 3: Mean values and SD of each language summary measure in each group.

	all patients		**Dominant**		**Non-dominant**		**control**	
	mean	SD	Mean	SD	mean	SD	mean	SD
word comprehension	9.49	1.10	9.40	1.31	9.57	0.83	10.00	0.00
sentence comprehension	7.63	2.08	7.19	2.36	8.07	1.64	9.86	0.22
word finding	9.79	0.44	9.69	0.57	9.89	0.20	10.00	0.00
grammatical construction	9.18	1.16	8.95	1.49	9.41	0.60	9.78	0.28
speech motor programming	9.20	1.40	9.09	1.76	9.32	0.88	10.00	0.00
Repetition	9.53	0.62	9.42	0.75	9.65	0.43	9.88	0.22
Reading	8.88	1.21	8.76	1.27	8.99	1.14	9.80	0.44
Overall	88.62	15.91	89.26	8.74	87.99	20.72	99.20	0.74

Word comprehension

Table 4: Word comprehension.

Word comprehension	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	9.4 vs 10	0.06	Not significant
Non-dominant stroke vs healthy	9.57 vs 10	0.03	significant
Dominant stroke vs non-dominant stroke	9.4 vs 9.57	0.6	Not significant

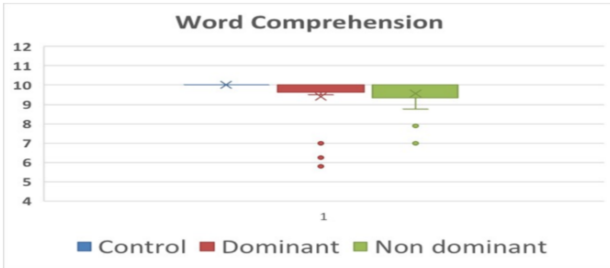

Figure 1: Word comprehension.

Regarding word comprehension in comparing dominant hemispheric stroke patients to healthy controls, the mean difference was not statistically significant. However, when comparing non-dominant hemispheric stroke patients to healthy controls, the mean difference was statistically significant. Interestingly, there was no statistically significant difference between the dominant and non-dominant groups.

Sentence comprehension:

Table 5: Sentence comprehension.

Sentence comprehension	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	7.19 vs 9.86	0.0001	significant
Non-dominant stroke vs healthy	8.07 vs 9.86	0.0001	significant
Dominant stroke vs non-dominant stroke	7.19 vs 8.07	0.189	Not significant

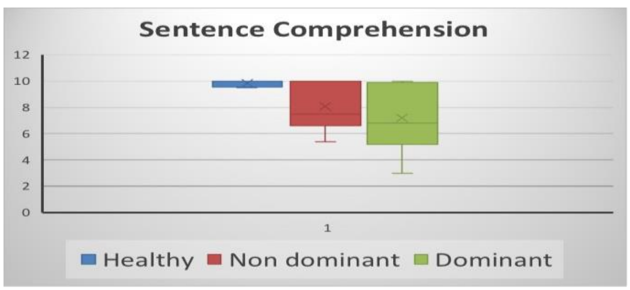

Figure 2: Sentence comprehension.

The analysis revealed statistically significant differences in mean scores for sentence comprehension between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. However, no statistically significant difference in mean scores was seen between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients for sentence comprehension.

Word finding:

Table 6: Word finding.

Word finding	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	9.68 vs 10	0.026	Significant
Non-dominant stroke vs healthy	9.89 vs 10	0.026	Significant
Dominant stroke vs non-dominant stroke	9.68 vs 9.89	0.151	Not significant

Figure 3: Word finding.

Regarding word finding statistically significant differences in mean scores were seen between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. However, no statistically significant difference in mean scores was found between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients.

Grammatical construction:

Table 7: Grammatical construction.

Grammatical construction	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	8.94 vs 9.77	0.026	Significant
Non-dominant stroke vs healthy	9.41 vs 9.77	0.021	Significant
Dominant stroke vs non-dominant stroke	8.94 vs 9.41	0.219	Not significant

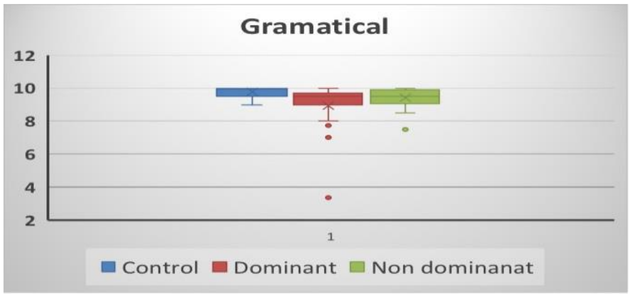

Figure 4: Grammatical construction

Regarding grammatical construction: The analysis showed statistically significant differences in mean scores between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. However, there was no statistically significant difference in mean scores between dominant and non-dominant hemisphere stroke patients.

Speech motor Programming:

Table 8: Speech motor Programming .

Speech motor Programming	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	9.087 vs 10	0.035	Significant
Non-dominant stroke vs healthy	9.317 vs 10	0.003	significant
Dominant stroke vs non-dominant stroke	9.087 vs 9.317	0.614	Not significant

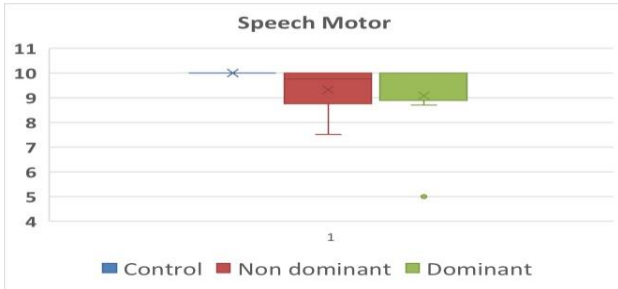

Figure 5: Speech motor Programming.

Regarding speech motor Programming: the statistical analysis revealed significant differences in mean scores between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. however, there was no significant difference in mean scores between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients.

Repetition:

Table 9: Repetition.

Repetition	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	9.41 vs 9.87	0.01	Significant
Non-dominant stroke vs healthy	9.64 vs 9.87	0.04	Significant
Dominant stroke vs non-dominant stroke	9.41 vs 9.64	0.26	Not significant

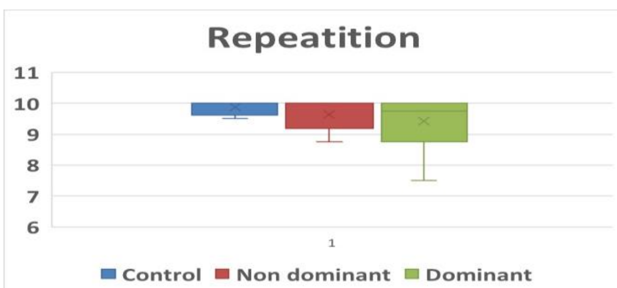

Figure 6: Repetition.

Regarding repetition: The analysis indicated that the difference in mean scores between dominant hemisphere stroke patients and healthy controls was statistically significant. Similarly, the difference in mean scores between non-dominant hemisphere stroke patients and healthy controls was also found to be statistically significant. However, there was no statistically significant difference in mean scores between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients.

Reading:

Table 10: Reading.

Reading	Mean score out of 10	p-value	significance
Dominant stroke vs healthy	8.76 vs 9.8	0.002	significant
Non-dominant stroke vs healthy	8.99 vs 9.8	0.007	significant
Dominant stroke vs non-dominant stroke	8.76 vs 8.99	0.56	Not significant

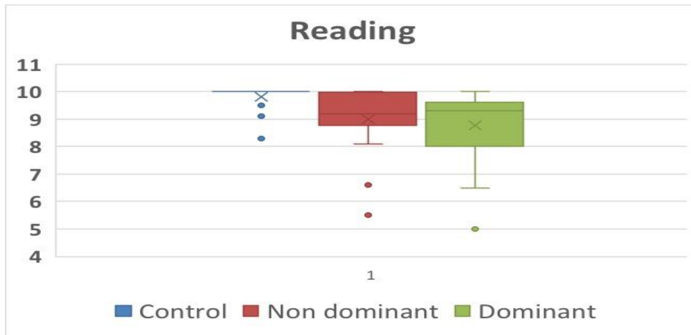

Figure 7 : READING

Regarding reading: Statistically significant differences were seen in mean scores between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. However, there was no statistically significant difference in mean scores between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients.

Overall:

Table 11: Overall.

Overall	Mean score out of 100	p-value	significance
Dominant stroke vs Healthy	89.25 vs 99.20	0.0001	Significant
Non-dominant stroke vs healthy	87.98 vs 99.20	0.02	significant
Dominant stroke vs non-dominant stroke	89.25 vs 87.98	0.80	Not significant

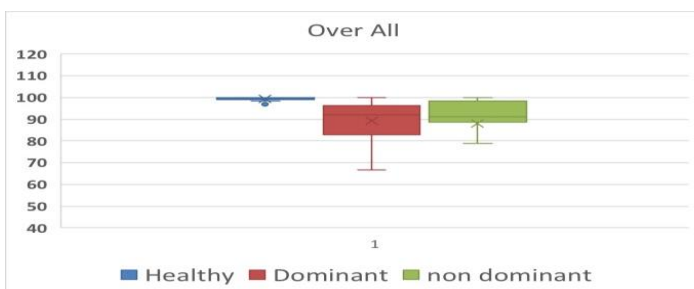

Figure 8: Overall.

Regrading overall score: Statistically significant differences were found in mean scores between dominant hemisphere stroke patients and healthy controls, as well as between non-dominant hemisphere stroke patients and healthy controls. However, the analysis revealed that there was no statistically significant difference in mean scores between dominant hemisphere stroke patients and non-dominant hemisphere stroke patients.

DISCUSSION:

In this study we are examining whether patients who had suffered from non-dominant hemisphere stroke developed language deficits or not, also we are trying to describe at which language subsets these deficits occurred using a quicker and simpler aphasia test which is the Quick aphasia battery to be able to apply it for even acute stroke patients then comparing our results with the previous research which used different aphasia tests aiming to encourage using this test routinely to right hemisphere stroke survivors and interpret the deficits in the subsets of language beyond merely broadly classifying it as receptive or expressive aphasia.In our study we examined participants who are right-handed and having either: right (non-dominant) stroke, left (dominant) stroke; and neurologically normal participants.

(Assuming that the left hemisphere is considered dominant for language in more than 95% of right-handers and in over 60 to 70% of left-handers.)(12).

By using quick aphasia test (22,23) and assessing each subset of language in each group:

We found that 30% of non-dominant hemisphere stroke patients had aphasia and 35% of dominant hemisphere stroke patient had aphasia and no aphasia was found in healthy controls in terms of overall degree less than 8.9 as the cutoff to have aphasia which is based on the documented correspondence between the QAB and the Western Aphasia Battery. In comparison to earlier Studies which have shown that the incidence of acquired language disorders ranges from 1-13% in right-handed individuals with right-hemisphere stroke(24.25), as reported by Alexander and Annett in 1996, and Coppens et al. in 2002. On the other hand, the incidence is higher at 18-38% in right-handed individuals with left-hemisphere stroke, according to Pedersen et al. in 1995.(26)

Regarding subsets of language which were impaired in each group:

- The task most often impaired after both dominant and non-dominant hemisphere stroke is sentence comprehension with a mean of 8.07 (SD = 1.64) for non-dominant hemisphere patient and a mean of 7.19 (SD = 2.36) for dominant hemisphere stroke patients and a mean of 9.86 (SD = 0.22) in healthy group and the more complex questions depending on syntactic representations, being most often mistaken by the patients e.g. Are doctors treated by patients? to compare this finding with Gajardo-Vidal et al.27 who discovered that individuals who had experienced a stroke in the right hemisphere were predominantly affected in their ability to match auditory sentences to pictures, particularly when dealing with more difficult semantically reversible sentences where the typical subject-verb-object structure had been reversed (e.g. 'The singer hits the soldier 'and 'The shoe under the pencil is blue').

- In our study focusing on word comprehension task, Specifically, we found that the difference in mean scores between the non-dominant hemisphere stroke group and the healthy group was statistically significant, Conversely, our analysis revealed that the difference in mean scores between the dominant stroke group and healthy group was statistically not significant and regrading grammatical construction task we found the dominant-hemisphere stroke patients showed impaired performance of a mean score of 8.95 (SD=1.49), while non-dominant hemisphere stroke patients showed slightly better performance with a mean score of 9.4 (SD = 0.60). So, our findings might be consistent with Previous studies on post-stroke aphasia which have indicated that the right hemisphere may play a larger role in speech comprehension compared to speech production (Zaidel, 1976; Crinion and Price, 2005)[28,5]. This might be related to non-linguistic cognitive processing and semantic retrieval abilities of the non-dominant hemisphere making it more crucial in language comprehension.

- ➢ Noting that in QAB the grammatical construction composed of connected speech examined by conversing the participant for at least 3 minutes after that also asking him to describe what he is seeing in a stimulus card to test the following (Agrammatism, reduced length and complexity, paragrammatism) and the average of sentence items from repetition and reading subsets. In our study, as mentioned above, the grammatical construction was more impaired in dominant hemisphere (LH) stroke patient than non-dominant hemispheric stroke patients; So, our findings might be consistent with Gajardo-Vidal et al[27] who found that in patients with left hemisphere stroke, the most frequently affected task was spoken picture description. Which might be explained by the important role of the dominant hemisphere in grammatical construction and programing motor commands necessary for speech production.

- Finally, regarding word finding, speech motor Programming, repetition, reading and overall results the difference in mean between dominant group and healthy group was statistically significant and difference in mean between non dominant group and control was also statistically significant but between the dominant and non-dominant groups was statistically not significant. Which points to the importance of both brain hemispheres in language comprehension and production with differences in some language subtypes as we noticed in the above comparisons highlighting the importance of examining both dominant and non-dominant hemispheric stroke patients for language deficits and due to the long time needed to finish most of aphasia batteries making it sometimes difficult to be applied in acute post stroke patients we recommend using other shorter batteries as the quick aphasia battery used in our study.

CONCLUSION AND RECOMMENDATIONS:

Non-dominant hemisphere had significant language processing abilities involving many subsets of language comprehension and production.

This function can be affected in non-dominant hemisphere stroke survivors so it is vital to be looked for regularly and measured so adaptations can be done by relatives and health workers for better life for post right hemispheric stroke patients.

Recommendations

For more ongoing research about this vital subject in terms of larger samples and more specific and practical tests methods to make more specification of the deficits and better management for the sufferer.

Abbreviations list.

Abbreviation	Description
DM	Diabetes Meletus
HTN	Hypertension
LH	Left hemisphere
RH	Right hemisphere
QAB	Quick aphasia battery

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