Thalamic Volume is Related to Side and Location of Stroke, Stroke Volume and Post-stroke Cognitive Impairment

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I. BACKGROUND

- Post-stroke cognitive impairment is a very common sign in patients with focal brain infarction, affecting up to 2/3 of stroke survivors[1].
- Our previous work showed: 1) post-stroke cognitive impairment relates to thalamic grey matter density[2]; 2) thalamic hyperintensities correlated with both verbal conceptualization and attention score[3]; and 3) anterior-medial thalamic lesions ≥55mm^3 correlated with sudden cognitive decline and dementia[4].
- Using neuropsychological and MRI protocols recommended by the Vascular cognitive impairment (VCI) harmonization criteria[5], we set out to see whether the thalamus volume changed due to focal stroke damage and to correlate thalamic volume and neuropsychological test scores.

II. OBJECTIVES

To examine the relationship between side and volume of the thalamus, chronic focal brain infarction and cognitive function.

III. METHODS

Participants:

- 59 subjects, 6-36 months post-infarct
- All subjects were administered
  (1) The 60 minute protocol, (2) 30 minute protocol[5]
  (3) Montreal Cognitive Assessment (MoCA)[6]
- MRI performed within 3 weeks of neuropsychological testing.

MR Technique:

GE, 3-Tesla (3D-T1, PD/T2, FLAIR)

1.Thalamus tracing (FIGURE1)
The border of each thalamus was visually identified and manually traced using triple magnified, intensity inverted, acpc-aligned, axial T1 with ANALYZE 8.0.

2. Stroke tracing (FIGURE2)
Focal infarcts were manually traced on T1, co-registered to FLAIR & PD/T2 including the peri-infarct hyperintense borderzone.

- All derived volumes were divided by total intracranial capacity (TIC) to correct for individual head size (normalized brain volume)[7].

Neuropsychological testing:

- The 60 and 30 minute protocols tested executive, language, visuospatial, and memory functions.
- Total and domain z scores were computed for the all cognitive tests.

Statistical Analysis:

- Paired sample t-test was used to: 1) compare ipsilateral vs. contralateral thalamic volume differences; and 2) compare the percentage of the stroke region to original stroke.
- Spearman Correlation was used to: 1) to correlate infarction volume with ipsilateral thalamic volume; and 2) to correlate neuropsychological z scores with thalamic volume.
- After the whole subjects analysis, the subjects were divided into anterior (frontal lobe and basal ganglia strokes) and posterior stroke (parietal, temporal, occipital lobes strokes) groups. Subjects were also divided in left and right hemisphere strokes.
- By multiple regression, thalamus volumes were used to predict scores on MoCA, 60, 30 minute tests, after correcting for age and education.

IV. RESULTS

TABLE1. Demographic and Brain-MRI variables

Variables (N=59)	Mean ± SD (median, range)
Age (years)	65.0 ±13.0 (62, 45-89)
Stroke side (L/R)	32 / 27
MMSE	27.2 ±3.0 (28, 20-30)
MRI	
TIC (cm^3)	1208 ±136
Infarct volume (cm^3)	29.3 ± 51.9
Ipsilateral thalamus volume (cm^3)	4.5 ± 1.4 *
Contralateral thalamus volume (cm^3)	5.3 ± 1.0 *

* p<0.0001(FIGURE4); TIC, total intracranial capacity

FIGURE4: Comparison between ipsilateral and contralateral thalamus volumes

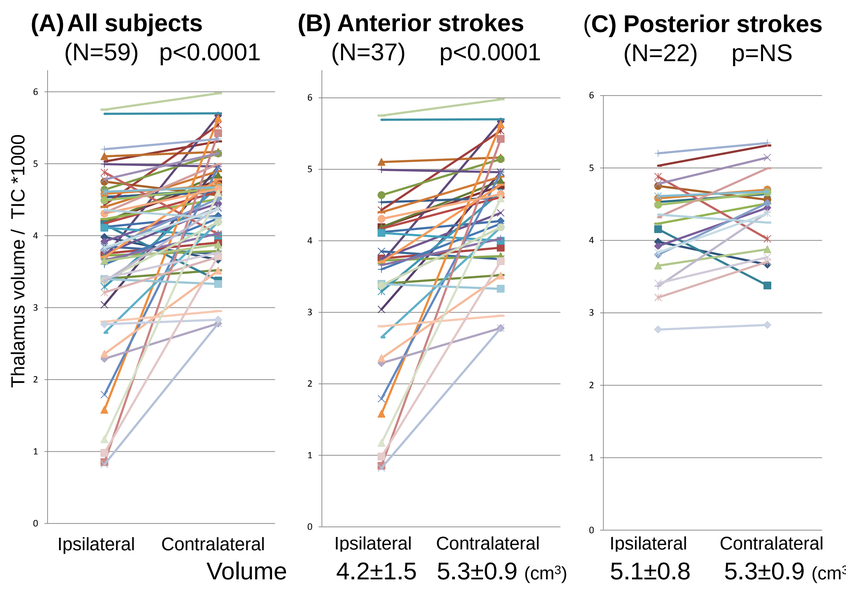


FIGURE5: Correlation between ipsilateral thalamus and stroke volume

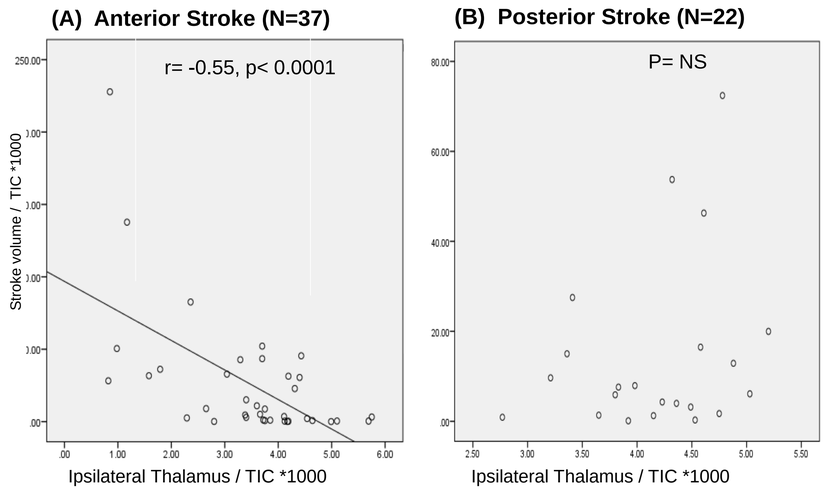


FIGURE1: Thalamus tracing

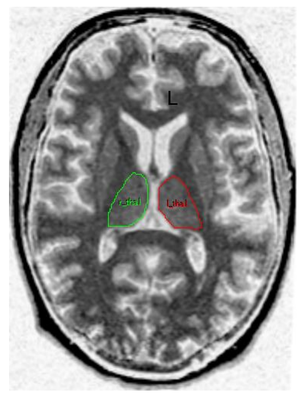


FIGURE2: Stroke tracing

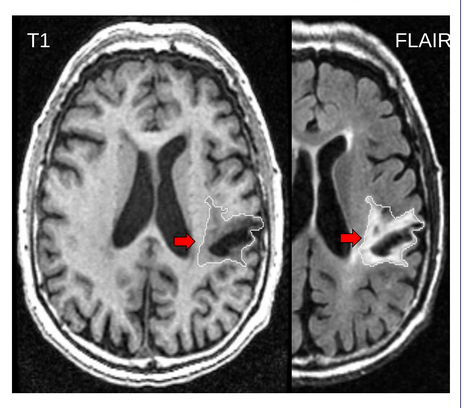


FIGURE3: Thalamus change in stroke
(a) Anterior stroke: smaller thalamus was seen on the left (ipsilateral) compared to the right
(b) Posterior stroke: no thalamus size difference

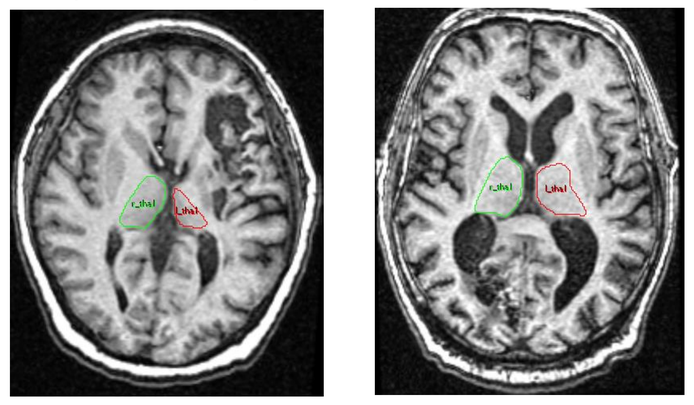


FIGURE6: Correlation – Ipsilateral thalamus and 30 Minute Z-score in anterior stroke subjects (accounting for age and years of education).

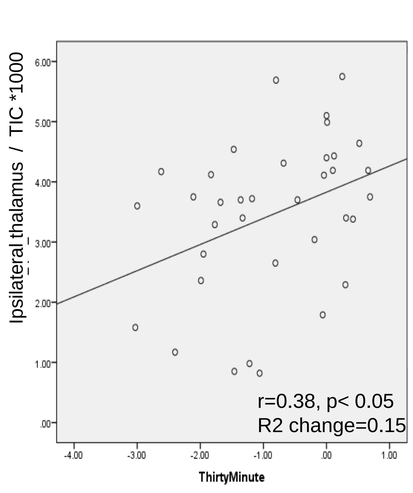
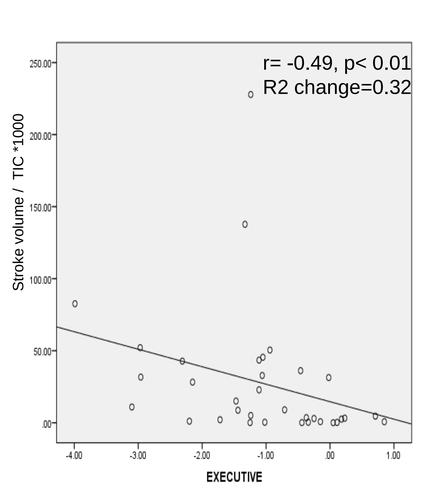


FIGURE7: Correlation – Infarct volume and executive Z-score in anterior stroke subjects (accounting for age and years of education).



V. DISCUSSION & CONCLUSIONS

- Ipsilateral thalamic shrinkage appeared only in anterior ischemic strokes.
- Previously, it was reported that secondary ipsilateral thalamic neurodegeneration occurred in stroke[8], but this was not studied in association with infarct location (anterior vs. posterior) or cognitive changes.
- Our finding may be because major fiber pathways connecting the thalamus to the cerebral cortex are mostly from/to the ipsilateral frontal lobe and basal ganglia.
- Correlations of 30 Minute protocol with the ipsilateral thalamic volume showed significance only in the anterior infarct patients. After accounting for age and years of education, Ipsilateral thalamic volume predicted only 30 Minute and Executive domain scores.
- No trends were seen in the posterior infarct group or the left and right stroke group.
- Thalamic "disconnection" may need to be considered in understanding post-stroke cognitive impairment.
- Cautionary note: 1) Almost half of the patients had multiple infarctions and some had white matter disease, which may also have affected cognitive functions; and 2) infarcts occurred in many brain regions. Sample size limited the ability to investigate relations between specific brain regions and cognition.

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References: 1) Madureira S, et al. *Eur J Neurology 2001.;* 2) Stebbins GT, et al. *Stroke 2008.*; 3) Swartz R et al. *JNNP 2006.*; 4) Swartz R et al. *Stroke 2008.*; 5) Hachinski V, et al, *Stroke 2006.;* 6) Nasreddine ZS et al. *J Am Geriatr Soc 2005.*; 7)Ramirez J et al. *Neuroimage 2011; 8) Schroeter M et al. Brain 2006.*