International Journal of
Physical Medicine & Rehabilitation

Gjelsvik et al., Int J Phys Med Rehabil 2014, S3
http://dx.doi.org/10.4172/2329-9096.S3-001

Research Article
Open Access

Trunk Control and Lesion Locations According to Alberta Stroke Program Early CT Score in Acute Stroke: A Cross-Sectional Study

Bente Elisabeth Bassøe Gjelsvik[1,2]*, Liv I. Strand[1,2], Halvor Naess[3], Håkon Hofstad[2,4], Jan StureSkouen[2,4], GeirEgil Eide[5] and Tori Smedal[1]

[1]Department of Physiotherapy, Haukeland University Hospital, Bergen, Norway
[2]Department of Global Public Health and Primary Care, Physiotherapy Research Group, University of Bergen, Bergen, Norway
[3]Department of Neurology, Haukeland University Hospital, Bergen, Norway
[4]Department of Physical Medicine and Rehabilitation, Haukeland University Hospital, Bergen, Norway
[5]Centre for Clinical Research, Haukeland University Hospital, Bergen, Norway

Abstract

Background: Stroke is a leading cause of disability in elderly people. Lesion location and size, and trunk control early after stroke have been found predictive of functional outcome. Trunk control is an important aspect of postural control, and commonly found to be impaired. A hemispheric difference in the regulation of postural control has been suggested, but limited knowledge of a relationship between specific lesions and trunk control exists.

Objective: To explore the relationship between middle cerebral artery (MCA) lesion locations and trunk control post stroke, and compare trunk control between patients with lesions in single and multiple locations, and between left and right hemispheres.

Methods: A cross-sectional design was used. Patients were recruited from a hospital stroke unit. Assessment tools: Trunk Impairment Scale–modified Norwegian version and Alberta Stroke Program Early CT Score (ASPECTS). Statistics: Descriptive, Independent t-test, Mann-Whitney's U-test, Chi-Square test.

Results:109 patients with first time middle cerebral artery lesions were included, 71 with multiple and 38 with single ASPECT locations. Trunk control was poorer in multiple (median 8.0) than in single (median 11.0) lesion locations, *P=0.011*. The most common single lesion locationswereM5 (50%) and internal capsule (18.4%). M5 is situated in the anterior parts of the MCA territory and hypothesized to represent sensory and motor areas of the cortex. Patients with lesions of M5 locations in the right hemisphere achieved poorer scores on trunk control than patients with left sided locations, *P=0.030*.

Conclusions: The results indicate that patients with lesions in multiple ASPECT locations have poorer trunk control than patients with single locations, and that trunk control is poorer after single right M5 lesions as compared to left. We recommend therapists to have specific attention towards trunk control in rehabilitation of patients with MCA lesions and especially with a right M5 location early post stroke.

Keywords: Stroke; Postural balance; Trunk control; Lesion location; Alberta stroke program early CT score; Trunk impairment scale-modified norwegian version; TIS-mod NV

Abbreviations: ASPECTS: Alberta Stroke Program Early CT Score; DWI: Diffusion-Weighted Imaging; ESD Stroke Bergen: Early Supported Discharge after stroke in Bergen; MRI: Magnetic resonance imaging; MCA: Middle cerebral artery; mRS: modified Rankin Scale; NIHSS: National Institutes of health Stroke Scale; TIS-modNV: Trunk Impairment Scale-modified Norwegian version

Introduction

Stroke is the most common cause of disability in the elderly population [1,2]. The long-term effect of stroke is determined by lesion location and size and by the extent of subsequent recovery [3-5], but there is limited knowledge of what impact specific lesions have on motor skills.

Trunk control is an important aspect of postural control, and is accordingly essential for balance, walking and other functional activities [6-9]. However, limited research has been undertaken to explore a possible impact of lesion location on trunk control in patients post stroke, possibly because the trunk seemsto be bilaterally innervated [10], and therefore assumed to cause less functional impairment as compared to the affected extremities [11]. Although the trunk has been found to be impaired in several studies [11-14], we only found two studies that explored hemispheric asymmetry related to trunk control in stroke [15,16], To the best of our knowledge, no studies have explored the possible relationship between trunk control and specific lesion locations, and there is therefore a need for more research in this area. Knowledge of such a relationship could give additional understanding of factors underlying functional problems seen in stroke and highlight a possible need to prioritize trunk retraining for certain patients early post stroke when the potential for recovery is greatest.

The middle cerebral artery (MCA) is the most common site for stroke [17]. A diagnostic tool used to investigate the location of acute stroke in the MCA territory is the Alberta Stroke Program Early CT Score (ASPECTS) [18,19]. The main objective of this study was to explore the relationship between middle cerebral artery lesion locations and trunk control post stroke, and to compare trunk control between patients with lesions in different single and multiple locations and between left and right hemispheres.

***Corresponding author:** Bente Elisabeth Bassøe Gjelsvik, Department of Physiotherapy, Haukeland University Hospital, Bergen, Norway, Tel: +47 55 97 54 51, +47 480 44 422; Fax: +47 55 97 60 88; E-mail: bente.elisabeth.bassoe.gjelsvik@helse-bergen.no

Received January 20, 2014; **Accepted** February 10, 2014; **Published** February 14, 2014

Citation: Gjelsvik BEB, Strand LI, Næss H, Hofstad H, StureSkouen J, et al. (2014) Trunk Control and Lesion Locations According to Alberta Stroke Program Early CT Score in Acute Stroke: A Cross-Sectional Study. Int J Phys Med Rehabil S3: 001. doi:10.4172/2329-9096.S3-001

Methods

Design

The study has a cross-sectional design and was conducted in the context of a larger randomized controlled trial; Early Supported Discharge after Stroke in Bergen (ESD Stroke Bergen) [20].

Patients

The patients were admitted to a university hospital stroke unit in Norway, from 2008 to 2011 with a 3 months follow-up. The patients were assessed for eligibility to the ESD Stroke Bergen by a stroke unit physician and recruited by a stroke nurse. Inclusion criteria: acute MCA lesion as diagnosed by Magnetic Resonance Imaging (MRI), living at home prior to the stroke, inclusion within 2-7 days after stroke onset and between 6 - 120 hours after admission to the stroke unit, and a National Institutes of Health Stroke Scale score (NIHSS) [21] of 2-26. Patients with NIHSS score <2 were included if the modified Rankin Scale (mRS) [22] score was ≥ 2. Written informed consent was obtained, and if this was not possible, consent was given by the next of kin, and the patients had to confirm this in writing as soon as they were able to. This procedure was approved by the regional ethics committee. Exclusion criteria: serious psychiatric disorders, current alcohol or substance abuse, severe co-morbidity rendering the patient too ill to be tested due to e.g. the acute stroke, serious heart condition or terminal cancer, or poor understanding of the Norwegian language. Additional exclusion criteria were added for the present study: previous stroke and additional lesions in the brain stem or cerebellum, and inability to sit upright unsupported for 10 seconds.

Data collection

Background information on age, gender, cohabitation, diabetes, previous nursing care, hemispheric lesion side and thrombolytic treatment were recorded. The Trunk Impairment Scale–modified Norwegian version (TIS-modNV) [23] was used to evaluate the stroke patients' quality of trunk control in sitting. A prerequisite for scoring is the ability to sit upright without support for 10 sec. The scale consists of 6 items giving a total sum of 0-16 points (16 highest). Item 1: sideflexion to the most affected side touching the plinth with the elbow; item 2: side flexion to the opposite side touching the plinth with the elbow. These two items evaluate the patients' ability to keep the pelvis stable and in contact with the base of support while at the same time selectively sideflexing the upper trunk (Figure 1 A). Item 3: lifting the most affected hip/pelvic half off the plinth; item 4: lifting the opposite hip/pelvic half off the plinth. These two items evaluate the patients' ability to keep the upper trunk stable while selectively weight transferring to one side to lift the opposite hip/pelvic half (Figure 1 B). Item 5: selective rotation of upper trunk while keeping the pelvis stable; and item 6: selective rotation of lower trunk by moving alternate knees forward while keeping the upper trunk stable. To achieve the full score on item 5 and 6, the patients have to complete the task within 6 seconds. The items are constructed as ordinal scales with scoring levels 0-3 (Items 1, 2, 5, 6) and 0-2 (Items 3, 4). A score of zero means that the patient is unable to perform the required task, and to achieve a top score the performance should be appropriate without compensation, i.e. optimal. The scale has demonstrated good construct validity, excellent internal consistency, as well as high inter-tester and test-retest reliability [23]. Four neurorehabilitation physiotherapists tested the patients' trunk control. They had practised testing several patients prior to this study to assure reliability within themselves.

Lesion location was determined by diffusion weighted MRI (DWI MRI) after admission to the hospital. DWI was performed as part of MRI on a 1.5 Tesla Siemens Magnetom (Symphony) using a DWI-sequence of ep2d_diff_3scan_trace with Field of view 230 mm, Slice thickness 5 mm, TR 3200 ms, TE 94 ms, as specification parameters [24]. The scans were scored by a senior consultant neurologist (HN) at the stroke unit using the Alberta Stroke Program Early CT Score (ASPECTS). ASPECTS were initially developed for CT, but as MRI technology has rapidly become the most frequently used imaging tool, ASPECTS is applied on DWI MRI (DWI ASPECTS) [19,25-28]. ASPECT scores 10 locations in the MCA territory [26,29]: 3 subcortical regions (internal capsule, the lentiform and caudate nuclei) and 7 cortical regions (insular cortex, M1 – M6). M1 to M6 are geometrical divisions of the MCA-territory, and not anatomical areas [29]. An ASPECTS sum of 10 indicates no lesions in the MCA-territory detected by DWI MRI, while an identifiable lesion in any of these regions results in a deduction of 1 point [30], i.e. two lesion locations would give an ASPECTS sum of eight. Number of lesion locations indicates the extent (size) of the lesion in the individual patient [26,30].

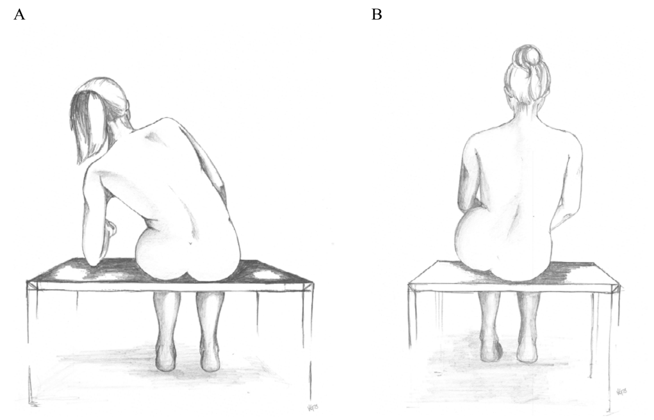

Figure 1: Illustrating items of the TIS-modNV. Illustration of optimal performance of A. lower trunk control items 1 and 2, and B. upper trunk control items 3 and 4 of the TIS-modNV scale. The illustrations highlight the selectivity of stability and movement during performance, however, during testing the patient and tester should sit facing eachother. © Karen Gjelsvik, 2013, reprinted with permission.

Data was collected for the ESD Stroke Bergen, and ethical approval was sought and given for the present study by the Norwegian Social Science Data Services and the Regional Committee for Medical and Health Research Ethics (project no. 2010/2462), which allowed data to be used without the patients giving separate consent.

Statistics

Descriptive statistics were used to examine background characteristics of all patients as well as gender differences for age and baseline TIS-modNV. Independent t-tests were used to compare age and Mann-Whitney's U-test to compare baseline TIS-modNV scores between men and women, and multiple and single lesion locations, as scores were not normally distributed. Independent t-test was used to compare age, and Mann-Whitney's U-test to compare other background variables between patients with multiple and single lesion locations. Descriptive statistics were used to explore baseline TIS-modNV scores in patients with lesions in multiple and single ASPECT locations, and Mann-Whitney's U-test to compare TIS-modNV scores between right and left hemispheres for single cortical, subcortical and individual ASPECT locations. The statistical programmes package SPSS 21 (SPSS Inc. Chicago, Illinois 60606) was used for all data analysis.

Results

Of 306 patients included in the ESD Stroke Bergen, 197 were excluded: 111 (36.3%) did not suffer MCA infarcts; 38 did not have MRI scans; four were too ill to be tested for trunk control and one patient was not available; 19 had previous strokes; 13 had additional strokes in cerebellum or brainstem; and 11 patients scored fully (no infarct detected) on ASPECTS but had clinical signs and symptoms of MCA infarction. One-hundred-and-nine patients fulfilled the inclusion criteria of the present study, of which 38 suffered lesions in single and 71 in multiple ASPECT locations. Background characteristics of all patients are shown in Table 1. For inclusion in the study, the ability to sit upright and unsupported was assessed at mean (SD), min-max: 4.5 (1.9), 1-9 days after stroke (missing information on 4 patients), at the same time as the patients were tested using TIS-modNV. The overall TIS-modNV sum scores were median/mean (SD), min - max: 10.0/9.0 (4.5), 0-16, and the patients were tested at mean (SD), min-max: 4.5 (1.9), 1-9 days after stroke (missing information on 4 patients).

There were no significant differences for any background variables between patients suffering lesions in multiple or single locations. The distribution of scores related to TIS-modNV in multiple and single ASPECT locations are shown in Table 2. There was a significant difference in overall trunk control between patients with multiple (median 8.0) and single (median 11.0) lesion locations, *P=0.011*, but both groups showed substantial variability in scores. The most frequent single lesion locations were M5 (n=19, 50%) and internal capsule (n=7, 18.4%), M5 was also the most frequent stroke site in multiple ASPECT locations. Patients with single lentiform nucleus or M5 lesion locations demonstrated the best trunk control. No patients suffered lesions in the single locations insular cortex, M2 or M3.

The distribution of TIS-modNV scores in single right and left hemispheric lesions is shown in Table 3. Patients with lesions of the right M5 (median 9.0) location tended to demonstrate poorer trunk control as compared to left (median 13.0), *p=0.030*.

Post hoc differences in trunk control between patients with lesions of right and left M5 locations (n = 19) were further explored regarding performance scores of each item on TIS-modNV (Table 4). The items are organized to display *lower and upper trunk control*, respectively. Comparing the frequency of patients achieving the different scoring alternatives, we found that more patients with right hemispheric lesions achieved poorer scores (0 or 1) in items 1, 4 and 6 as compared to left (Table 4).

Variables			
Age; *mean*, SD, *range*	70.6	14.4	[27, 93]
Gender; *n (%)*			
Male	53	48.6	
Female	56	51.4	
Cohabitation; *n (%)*			
Living alone	50	45.9	
Living with partner	59	54.1	
Diabetes; *n (%)*	9	8.3	
Previous nursing care; *n (%)*	6	5.5	
Thrombolytic intervention; *n (%)*	24	22.0	
Lesions; *n (%)*			
Multiple	71	65.1	
Single	38	34.9	
Lesion side; *right/left/bilateral, n (%)*			
Right	46	42.2	
Left	61	56.0	
Bilateral	2	1.8	
ASPECTS sum; *median, IQR, range*[a]	8	2.0	[2, 9]

Abbreviations: ASPECTS: Alberta Stroke Program Early CT Score based on diffusion weighted magnetic resonance imaging (DWI MRI);IQR: interquartile range. [a]ASPECTS: no lesions = 10 points, a patient with a score of 9 has one lesion

Table 1: Background characteristics of the sample, N=109.

Discussion

Trunk control has been found to be associated with balance and functional ability [31,32], functional change and destination at discharge [33], and to predict functional outcome at 6 months post stroke better than Barthel Index [34]. Trunk impairments may potentially be one explanatory factor for the patients' level of disability post stroke as seen in clinical practice.

This study explored the relationship between trunk control and locations of acute MCA lesions as evaluated with ASPECTS. Most patients had lesions in multiple locations and tended to display poorer trunk control than patients with single lesion locations. We found significant differences in trunk control between single right and left M5 lesion locations, with right hemispheric lesions demonstrating poorer trunk control than left, specifically for items 1, 4 and 6 of the TIS-modNV.

Patients with multiple lesion locations could have lesions in any combination of locations; for these patients it is not possible to infer any causal relationship as to which location(s) might be most responsible for deficits in trunk control. To explore the impact of lesions in the different locations, we therefore chose to look more closely at patients suffering lesions in single locations. Best trunk control was found in patients with lesions of the lentiform nucleus and M5 in single ASPECT locations (Table 2), but in single locations we also found significant difference in trunk control between the right and left M5 (Table 3). The results regarding hemispheric differences show a tendency towards poorer trunk control after right hemispheric lesions, both when looking at all single locations together and for cortical locations alone, but the sample was too small to draw any firm conclusions. This result might also be due to the significant hemispheric difference in trunk control with lesions of M5 locations.

Our results add to previous findings of hemispheric differences regarding postural control. Manor et al. [35] investigated the dependence upon vision and non-lesioned regional brain tissue volumes for postural control in patients with right and left MCA lesions using MRI. They found that right hemispheric lesions were associated with greater postural sway velocity, range and variability in standing with eyes closed as opposed to eyes open, compared to patients with left MCA lesions and controls. Other researchers [36-38] have also found that patients with right hemispheric lesions seem to display the poorest postural control. Abe et al. [39] found significantly higher prevalence for pushing behavior, a disorder of the upright body orientation with respect to gravity [39,40], in patients with acute right hemispheric lesions as compared to left and thereby poorer postural control. We have only found two studies on hemispheric asymmetry related specifically to trunk control in stroke, and these demonstrated poorer postural stability in sitting in patients with right hemispheric lesions as compared to left [15,16]. Previous studies therefore suggest a differentiation between the right and left hemisphere in the regulation of postural and trunk control, which is supported by the results of our study.

We have not found any studies investigating the relationship between trunk or postural control and lesion location using ASPECTS. However, lesion location related to balance has recently

	TIS-mod NV baseline scores									
ASPECT	**Multiple locations (n = 71)[a]**					**Single locations (n = 38)**				
Locations	**n**	**median**	**mean**	**SD**	**range**	**n**	**median**	**mean**	**SD**	**range**
All	225	8.0	8.2	4.5	[0, 15]	38	11.0	10.5	4.2	[2, 16]
Caudate nucleus	8	5.0	5.0	3.9	[0, 12]	1	4.0			
Lentiform nucleus	28	7.0	7.0	4.2	[0, 15]	4	14.5	14.0	2.5	[11, 16]
Internal capsule	5	9.0	7.8	5.9	[0, 15]	7	8.0	9.7	3.5	[6, 15]
Insular cortex	32	8.0	7.6	5.1	[0, 15]	0				
M1	26	11.0	9.5	4.8	[0, 15]	1	2.0			
M2	23	6.0	6.0	5.2	[0, 15]	0				
M3	12	6.5	5.7	4.7	[0, 12]	0				
M4	17	11.0	7.7	5.3	[0, 15]	4	7.0	8.8	5.0	[5, 16]
M5	53	8.0	7.8	4.7	[0, 15]	19	12.0	11.5	3.8	[2, 16]
M6	21	7.0	6.2	4.6	[0, 15]	2	8.5	8.5	3.5	[6, 11]

ASPECT: Alberta Stroke Program Early CT based on diffusion weighted magnetic resonance imaging (DWI MRI); TIS-modNV: Trunk Impairment Scale – modified Norwegian version, sum score 0 – 16 (16 best). aBilateral lesions (n=2) included. Statistical test: Mann-Whitney's U test`

Table 2: Distribution of baseline TIS-modNV scores in multiple and single ASPECT locations, N=109.

	TIS-modNV baseline scores										
ASPECT	**Right hemisphere**					**Left hemisphere**					
Locations	**n**	**median**	**mean**	**SD**	**range**	**n**	**median**	**mean**	**SD**	**range**	***P-value***
All single lesions	15	8.0	8.8	4.7	[2, 16]	23	12.0	11.7	3.4	[5, 16]	*0.068*
Cortical	11	8.0	8.5	4.7	[2, 16]	15	12.0	12.0	3.4	[5, 16]	*0.065*
Subcortical	4	10.0	9.8	5.6	[4, 15]	8	10.5	11.1	3.6	[7, 16]	*0.525*
Individual locations											
Caudate nucleus	1	4.0				0					
Lentiform nucleus	0					4	14.5	14.0	2.5	[11, 16]	
Internal capsule	3	14.0	11. 7	4.9	[6, 15]	4	8.0	8.3	1.3	[7, 10]	*0.571*
Insular cortex	0					0					
M1	1	2.0				0					
M2	0					0					
M3	0					0					
M4	3	8.0	10.0	5.3	[6, 16]	1	5.0				*0.500*
M5	7	9.0	8.7	4.3	[2, 14]	12	13.0	13.1	2.3	[9, 16]	***0.030***
M6	0					2	8.5	8.5	3.5	[6, 11]	

Abbreviations: ASPECT: Alberta Stroke Program Early CT based on diffusion weighted magnetic resonance imaging (DWI MRI);TIS-modNV: Trunk Impairment Scale – modified Norwegian version. Cortical locations are insular cortex and M1 – M6, subcortical locations are caudate and lentiform nuclei, and internal capsule. Statistical test is Mann-Whitney's U test. Significant differences in bold

Table 3: Comparison of baseline TIS-modNV scores between single right and left hemispheric locations, N=38.

			Scoring levels; n (%)								
			Right				**Left**				**P-value**
Construct		**Description of items**	**0 Unable**	**1**	**2**	**3 Optimal**	**0 Unable**	**1**	**2**	**3 Optimal**	
Lower trunk control Sitting, stable pelvis, movement of upper trunk; n (%)	Item 1	Sideflexion to most affected side	1 (14.3)	2 (28.6)	2 (28.6)	2 (28.6)	0	0	2 (16.7)	10 (83.3)	***0.009***
	Item 2	Sideflexion to least affected side	0	1 (14.3)	2 (28.6)	4 (57.1)	0	1 (8.3)	2 (16.7)	9 (75.0)	*0.518*
	Item 5	Rotation of upper trunk	1 (14.3)	3 (42.9)	0	3 (42.9)	0	3 (25.0)	3 (25.0)	6 (50.0)	*0.358*
Upper trunk control Sitting, stable upper trunk, movement of lower trunk and pelvis; n (%)	Item 3*	Lifting most affected pelvic half	3 (42.9)	2 (28.6)	2 (28.6)		3 (25.0)	0	9 (75.0)		*0.206*
	Item 4*	Lifting least affected pelvic half	2 (28.6)	2 (28.6)	3 (42.9)		0	2 (16.7)	10 (83.0)		***0.044***
	Item 6	Rotation of lower trunk	3 (42.9)	3 (42.9)	0	1 (14.3)	0	6 (50.0)	0	6 (50.0)	***0.043***

Abbreviations: TIS-modNV: Trunk Impairment Scale – Norwegian version. The items are organized according to Lower and Upper trunk, which relates to the stability required to perform the movement: lower trunk stability to move the upper trunk selectively, and upper trunk stability to selectively move the lower trunk. *In items 3 and 4, top score = 2. Statistical test: Chi-Square test, Linear-by-Linear Association, Exact Sig. (2-sided)

Table 4: Frequency of TIS-modNV scores within each item for right (n=7) and left (n=12) M5 lesion locations, N=19.

been investigated in patients with stroke [41,42] using functional near-infrared spectroscopy (fNIRS) [42-44]. fNIRS is a portable brain imaging technique with fiber optic cables mounted in a wearable head cap, and uses low levels of light to measure blood flow and blood oxygenation changes in the brain. This system gives similar information as functional magnetic resonance imaging (fMRI), but unlike fMRI it allows the patient to be upright or even ambulatory during imaging [43]. Fujimoto et al. [41] explored recovery of balance in 20 patients 2-3 months post stroke using a movable platform and fNIRS, and found that the supplementary motor area (SMA) might play a role in postural control. The SMA has also previously been suggested to have a role in postural control [45]. Mihara et al. investigated balance using a moving platform and fNIRS in 15 healthy individuals [44] and 20 patients in the subacute to chronic stage post stroke [42]. They suggested that a broad cortical network including prefrontal, premotor, SMA and parietal cortical areas are involved in postural control in both healthy individuals as well as in patients post stroke. A variety of experimental settings using different ways of exploring balance and recording cortical activity make comparisons between studies difficult, however, results from studies mentioned above would seem to indicate that the cortex plays a substantial role in postural control. Whether this is related to the acute lesion or functional reorganization over time requires further study. We found a difference in trunk control between the right and left hemispheric M5 location within the first week after stroke onset. As ASPECT divides the MCA territory into geometrical and not functional areas, it is not possible to give an exact functional correlate to the different locations. However, M5 is located within the anterior parts of the MCA territory and is hypothesized to represent sensory and motor areas of the cortex (personal communication with neuroanatomist Per Brodal). If this is the case, the sensory and motor aspects of the right hemisphere would seem important for the postural role of the trunk and lesions in this area could possibly explain some of the impairments seen in trunk control early after stroke. *Post hoc* analysis showed differences in trunk control between lesions in left and right M5 locations.Patients with right hemispheric lesions would therefore seem to have greater impairments in trunk control as compared to left, specifically for TIS-modNV items 1, 4 and 6.

Limitations

We chose to explore the impact on trunk control of lesions related to the MCA territory using ASPECTS. According to Balaban et al. [17] the MCA territory is the most frequent site for stroke, however, of the original sample included in the ESD Stroke Bergen we excluded nearly half: 149 (48.7%) patients, as they did not suffer MCA lesions or did not have MRI scans. A possible relation between trunk control and lesion location was therefore not examined for a considerable portion of the patients.Lesions of the brain stem and cerebellum are known to be associated with balance problems [46], and patients with additional lesions in these areas were excluded from the study as well as patients with previous strokes. Comparisons between lesions of the right and left hemisphere for caudate and lentiform nuclei, insular cortex, M1-M3, and M6 was not possible as there were too few patients with lesions in these locations. For internal capsule and M4 no significant differences were found, and there were too few patients to draw any conclusions as for a possible hemispheric difference in trunk control. Our results are therefore related to M5 alone. We did not record the patients' handedness, and therefore we do not know whether the regulation of trunk control is different with right or left dominant side.

Clinical relevance

Expanding the knowledge of trunk control and its association with lesion location has clinical relevance.Our results demonstrated a hemispheric difference for M5 in the regulation of trunk control. AsM5 is located within the anterior parts of the MCA territory which is hypothesized to represent sensory and motor areas of the cortex, the right M5 location could be hypothesized to have a greater role in the regulation of trunk control than left.Early information about lesion location together with assessment of trunk control may help guide therapists in their treatment choices and emphasis in intervention, which ultimately may positively affect the patients overall function and independence. Several authors recommend interventions aimed at improving trunk control post stroke [13,14,47-51], and this is also recommended in a recent systematic review [52].

Further research

More research is needed to further explore the possible relationship between trunk control and different lesion locations and also with the patient's handedness taken into consideration. The relationship between lesion location and trunk control versus functional recovery remains to be investigated.

Conclusion

The results of our study indicate that patients with lesions in multiple ASPECT locations have poorer trunk control than patients with single locations early after stroke, and that trunk control is poorer after single right M5 lesions as compared to left. We recommend therapists to have specific attention towards trunk control in rehabilitation of patients with MCA lesions and especially with a right M5 location early post stroke.

Acknowledgement

The authors wish to thank all patients and clinicians who gave significant contributions towards making the study possible: research coordinator Silje Mæhle Haugland; nurse Signe Gjærum, responsible for recruiting the patients; and the physiotherapists who tested the patients: Torunn Grenstad, Veronica Bøe, Odd-Arne Bergset, and Elisabeth Skjefrås Kvile. This work was supported by the Research Council of Norway (grant number 186528), Bergen Health Authority and the Regional Health Authority of Western Norway (no grant numbers).

References

1. Academy of Medical Sciences (2004) Restoring neurological function. Putting the neurosciences to work in neurorehabilitation. Academy of Medical Sciences London.
2. Helsedirektoratet (2010) Hjerneslag - Nasjonale retningslinjer for behandling og rehabilitering ved hjerneslag.
3. Chen CL, Tang FT, Chen HC, Chung CY, Wong MK (2000) Brain lesion size and location: effects on motor recovery and functional outcome in stroke patients. Arch Phys Med Rehabil 81: 447-452.
4. Langhorne P, Bernhardt J, Kwakkel G (2011) Stroke rehabilitation. Lancet 377: 1693-1702.
5. Pan SL, Wu SC, Wu TH, Lee TK, Chen TH (2006) Location and size of infarct on functional outcome of noncardioembolic ischemic stroke. Disabil Rehabil 28: 977-983.
6. Davies PM (1990) Problems associated with the loss of selective trunk activity in hemiplegia. Right in the middle 31-65.
7. Fujiwara T, Sonoda S, Okajima Y, Chino N (2001) The relationships between trunk function and the findings of transcranial magnetic stimulation among patients with stroke. J Rehabil Med 33: 249-255.
8. Karthikbabu S, Chakrapani M, Ganeshan S, Rakshith KC, Nafeez S, et al. (2012) Prem V. A review on assessment and treatment of the trunk in stroke: A need or luxury. Neural Regen Res 7: 1974-1977.
9. Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, et al. (2006) Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil 20: 451-458.
10. Carr LJ, Harrison LM, Stephens JA (1994) Evidence for bilateral innervation of certain homologous motoneurone pools in man. J Physiol 475: 217-227.
11. Dickstein R, Shefi S, Marcovitz E, Villa Y (2004) Anticipatory postural adjustment in selected trunk muscles in post stroke hemiparetic patients. Arch Phys Med Rehabil 85: 261-267.
12. Geurts AC, de Haart M, van Nes IJ, Duysens J (2005) A review of standing balance recovery from stroke. Gait Posture 22: 267-281.
13. Karatas M, Cetin N, Bayramoglu M, Dilek A (2004) Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil 83: 81-87.
14. Ryerson S, Byl NN, Brown DA, Wong RA, Hidler JM (2008) Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol Phys Ther 32: 14-20.

15. Pérennou DA, Leblond C, Amblard B, Micallef JP, Rouget E, et al. (2000) The polymodal sensory cortex is crucial for controlling lateral postural stability: evidence from stroke patients. Brain Res Bull 53: 359-365.

16. Spinazzola L, Cubelli R, Della Sala S (2003) Impairments of trunk movements following left or right hemisphere lesions: dissociation between apraxic errors and postural instability. Brain 126: 2656-2666.

17. Balaban B, Tok F, Yavuz F, YaÅŸar E, Alaca R (2011) Early rehabilitation outcome in patients with middle cerebral artery stroke. Neurosci Lett 498: 204-207.

18. Barber PA, Demchuk AM, Zhang J, Buchan AM (2000) Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. ASPECTS Study Group. Alberta Stroke Programme Early CT Score. Lancet 355: 1670-1674.

19. Tei H, Uchiyama S, Usui T, Ohara K (2011) Diffusion-weighted ASPECTS as an independent marker for predicting functional outcome. J Neurol 258: 559-565.

20. Hofstad H, Naess H, Moe-Nilssen R, Skouen JS (2013) Early supported discharge after stroke in Bergen (ESD Stroke Bergen): a randomized controlled trial comparing rehabilitation in a day unit or in the patients' homes with conventional treatment. Int J Stroke 8: 582-587.

21. Adams HP Jr, Davis PH, Leira EC, Chang KC, Bendixen BH, et al. (1999) Baseline NIH Stroke Scale score strongly predicts outcome after stroke: A report of the Trial of Org 10172 in Acute Stroke Treatment (TOAST). Neurology 53: 126-131.

22. Govan L, Langhorne P, Weir CJ (2009) Categorizing stroke prognosis using different stroke scales. Stroke 40: 3396-3399.

23. Gjelsvik B, Breivik K, Verheyden G, Smedal T, Hofstad H, et al. (2012) The Trunk Impairment Scale - modified to ordinal scales in the Norwegian version. Disabil Rehabil 34: 1385-1395.

24. Naess H, Brogger JC Jr, Idicula T, Waje-Andreassen U, Moen G, et al. (2009) Clinical presentation and diffusion weighted MRI of acute cerebral infarction. The Bergen Stroke Study. BMC Neurol 9: 44.

25. Barber PA, Hill MD, Eliasziw M, Demchuk AM, Pexman JH, et al. (2005) Imaging of the brain in acute ischaemic stroke: comparison of computed tomography and magnetic resonance diffusion-weighted imaging. J Neurol Neurosurg Psychiatry 76: 1528-1533.

26. de Margerie-Mellon C, Turc G, Tisserand M, Naggara O, Calvet D, et al. (2013) Can DWI-ASPECTS substitute for lesion volume in acute stroke? Stroke 44: 3565-3567.

27. Puetz V, Dzialowski I, Hill MD, Demchuk AM (2009) The Alberta Stroke Program Early CT Score in clinical practice: what have we learned? Int J Stroke 4: 354-364.

28. Terasawa Y, Kimura K, Iguchi Y, Kobayashi K, Aoki J, et al. (2010) Could clinical diffusion-mismatch determined using DWI ASPECTS predict neurological improvement after thrombolysis before 3 h after acute stroke? J Neurol Neurosurg Psychiatry 81: 864-868.

29. Pexman JH, Barber PA, Hill MD, Sevick RJ, Demchuk AM, et al. (2001) Use of the Alberta Stroke Program Early CT Score (ASPECTS) for assessing CT scans in patients with acute stroke. AJNR Am J Neuroradiol 22: 1534-1542.

30. Kosior RK, Lauzon ML, Steffenhagen N, Kosior JC, Demchuk A, et al. (2010) Atlas-based topographical scoring for magnetic resonance imaging of acute stroke. Stroke 41: 455-460.

31. Jijimol G, Fayaz RK, Vijesh PV (2013) Correlation of trunk impairment with balance in patients with chronic stroke. NeuroRehabilitation 32: 323-325.

32. Likhi M, Jidesh VV, Kanagaraj R, George JK (2013) Does trunk, arm, or leg control correlate best with overall function in stroke subjects? Top Stroke Rehabil 20: 62-67.

33. Di Monaco M, Trucco M, Di Monaco R, Tappero R, Cavanna A (2010) The relationship between initial trunk control or postural balance and inpatient rehabilitation outcome after stroke: a prospective comparative study. Clin Rehabil 24: 543-554.

34. Verheyden G, Nieuwboer A, De Wit L, Feys H, Schuback B, et al. (2007) Trunk performance after stroke: an eye catching predictor of functional outcome. J Neurol Neurosurg Psychiatry 78: 694-698.

35. Manor B, Hu K, Zhao P, Selim M, Alsop D, et al. (2010) Altered control of postural sway following cerebral infarction: a cross-sectional analysis. Neurology 74: 458-464.

36. Baier B, Janzen J, Müller-Forell W, Fechir M, Müller N, et al. (2012) Pusher syndrome: its cortical correlate. J Neurol 259: 277-283.

37. Rode G, Tiliket C, Boisson D (1997) Predominance of postural imbalance in left hemiparetic patients. Scand J Rehabil Med 29: 11-16.

38. Rode G, Tiliket C, Charlopain P, Boisson D (1998) Postural asymmetry reduction by vestibular caloric stimulation in left hemiparetic patients. Scand J Rehabil Med 30: 9-14.

39. Abe H, Kondo T, Oouchida Y, Suzukamo Y, Fujiwara S, et al. (2012) Prevalence and length of recovery of pusher syndrome based on cerebral hemispheric lesion side in patients with acute stroke. Stroke 43: 1654-1656.

40. Karnath HO, Broetz D (2003) Understanding and treating "pusher syndrome". Phys Ther 83: 1119-1125.

41. Fujimoto H, Mihara M, Hattori N, Hatakenaka M, Kawano T, et al. (2014) Cortical changes underlying balance recovery in patients with hemiplegic stroke. Neuroimage 85 Pt 1: 547-554.

42. Mihara M, Miyai I, Hattori N, Hatakenaka M, Yagura H, et al. (2012) Cortical control of postural balance in patients with hemiplegic stroke. Neuroreport 23: 314-319.

43. Karim H, Fuhrman SI, Sparto P, Furman J, Huppert T (2013) Functional brain imaging of multi-sensory vestibular processing during computerized dynamic posturography using near-infrared spectroscopy. Neuroimage 74: 318-325.

44. Mihara M, Miyai I, Hatakenaka M, Kubota K, Sakoda S (2008) Role of the prefrontal cortex in human balance control. Neuroimage 43: 329-336.

45. Penfield W, Welch K (1951) The supplementary motor area of the cerebral cortex; a clinical and experimental study. AMA Arch Neurol Psychiatry 66: 289-317.

46. Kandel ER, Schwartz JH, Jessell TM, Steven A. Siegelbaum, Hudspeth AJ (2000) Principles of neural science. (4th Edn), McGraw-Hill, New York 320 & 841.

47. Hacmon RR, Krasovsky T, Lamontagne A, Levin MF (2012) Deficits in intersegmental trunk coordination during walking are related to clinical balance and gait function in chronic stroke. J Neurol Phys Ther 36: 173-181.

48. Jandt SR, Caballero RM, Junior LA, Dias AS (2011) Correlation between trunk control, respiratory muscle strength and spirometry in patients with stroke: an observational study. Physiother Res Int 16: 218-224.

49. Reisman DS, Scholz JP (2006) Workspace location influences joint coordination during reaching in post-stroke hemiparesis. Exp Brain Res 170: 265-276.

50. Tanaka S, Hachisuka K, Ogata H (1998) Muscle strength of trunk flexion-extension in post-stroke hemiplegic patients. Am J Phys Med Rehabil 77: 288-290.

51. Winzeler-Merçay U, Mudie H (2002) The nature of the effects of stroke on trunk flexor and extensor muscles during work and at rest. Disabil Rehabil 24: 875-886.

52. Cabanas-Valdés R1, Cuchi GU2, Bagur-Calafat C1 (2013) Trunk training exercises approaches for improving trunk performance and functional sitting balance in patients with stroke: a systematic review. NeuroRehabilitation 33: 575-592.

This article was originally published in a special issue, **Stroke Rehabilitation** handled by Editor. Naoyuki Takeuchi, Hospital of Tohoku University, Japan, Shu Morioka, Kio University, Japan

Citation: Gjelsvik BEB, Strand LI, Næss H, Hofstad H, StureSkouen J, et al. (2014) Trunk Control and Lesion Locations According to Alberta Stroke Program Early CT Score in Acute Stroke: A Cross-Sectional Study. Int J Phys Med Rehabil S3: 001. doi:10.4172/2329-9096.S3-001