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Determinants of post stroke cognitive impairment: analysis from VISTA.

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Abstract:

Background: Post stroke cognitive impairment (PSCI) occurs commonly and is linked with development of dementia. We investigated the relationship between demographic, clinical and stroke symptoms at stroke onset and the presence of PSCI at 1 and 3 years after stroke.

Methods: We accessed anonymised data from the Virtual International Stroke Trial Archive (VISTA), including demographic and clinical variables. PSCI was defined as a Mini Mental State Examination (MMSE) score of ≤ 26 . We assessed univariate relationships between baseline stroke symptoms and PSCI at 1 and 3 years following stroke, retaining the significant and relevant clinical factors as covariates in a final adjusted logistic regression model.

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Results: We analysed data on 5435 patients with recent (median 33 days) stroke or TIA.

Mean ($\pm$ SD) age was 62.6 ($\pm$ 12.6) years, 3476 (65%) patients were male. Follow up data were available for 2270 and 1294 patients at one and three years, respectively. At one year, 781 (34%) patients had MMSE $\leq$ 26, at three years 391 (30%) had MMSE $\leq$ 26. After adjusting for age, stroke severity, hypertension, diabetes and type of qualifying event, initial stroke impairment (leg paralysis) was associated with increased rate of PSCI at one year (OR=1.62; 95% CI=1.20-2.20) and at three years (OR=1.95; 95% CI=1.23-3.09). Associations were consistent on subgroup analysis restricted to ischaemic stroke and transient ischaemic attack (N=4992).

Conclusions: Beside well-known determinants of PSCI such as age, stroke severity and presence of vascular risk factors, also leg paralysis is associated with subsequent of PSCI up to 3 years after stroke.

Introduction

Post stroke cognitive impairment (PSCI) is a term that refers to patients who develop cognitive deficits after stroke. It represents an important subset of patients with vascular cognitive impairment, and can progress to dementia in up to a third of stroke patients^{1,2}. Post-stroke dementia is one of the main causes of functional dependency^{2,3,4} and mortality after stroke⁵. It is therefore important to seek for factors associated with PSCI that, if modified, may prevent progression of cognitive deficits.

Several factors have been associated to post stroke cognitive deficits⁴. Pendlebury and Rothwell reviewed 73 cohort studies of post-stroke dementia in a total of 7511 patients and found that most predictors of post-stroke dementia were related to the stroke itself (haemorrhagic stroke, left hemisphere stroke, dysphasia, stroke severity, and infarct

volume), the number of strokes (previous stroke, multiple infarcts, and recurrent stroke) and the complications of stroke (incontinence, early seizures, acute confusion, hypoxic ischaemic episodes, and hypotension). Others factors included demographic features (older age, low educational attainment, previous cognitive decline, and premorbid disability), and vascular risk factors (diabetes and atrial fibrillation) ⁶. However, there was substantial heterogeneity among the studies in terms of setting, inclusion or exclusion of patients with pre-stroke dementia, whether only first-ever, any or only recurrent strokes were included, and the method of dementia diagnosis. Moreover, relationship between clinical stroke features of the acute event (i.e. stroke symptoms) and cognitive performance are less well described.

The aim of the present study was to expand the above findings for post-stroke dementia in a large and independent dataset, and to specifically investigate the associations between demographical, clinical and stroke features and PSCI in patients with recent stroke or transient ischaemic attack.

Methods

We conducted a retrospective analysis of individual patient level data from the Virtual International Stroke Trial Archive (VISTA). VISTA is an academic collaboration which provides access to existing patient trial data to perform exploratory analyses with the aim to help planning and design of future clinical trials ⁷. Ethical approval was not required since data were anonymised.

Our study population included patients with first ever brain vascular event, including ischaemic stroke, hemorrhagic stroke, transient ischaemic attack (TIA). We excluded Subarachnoid haemorrhages.

Clinical variables of interest included age, sex, hypertension, diabetes, atrial fibrillation, ischaemic heart disease, hypercholesterolemia, depression (history of), cigarette smoke exposure. Functional status at baseline was assessed with the Oxford Handicap Scale (OHS) ⁸.

Baseline stroke symptoms included clinical evaluation of arm and leg weakness, sensory deficit, aphasia, neglect, hemianopia dichotomized as presence/absence at stroke onset.

All patients underwent global assessment to define stroke subtype, including radiological exams (CT or MR), extensive blood tests, thoracic and neck vessels imaging and cardiac assessment where appropriate.

Cognitive function among survivals at one and three years was assessed on voluntary basis using MMSE, defining cognitive impairment as a score of $MMSE \leq 26$ ⁹.

We described the characteristics of study population at baseline, one and three years.

Furthermore, we described the differences in baseline characteristics of patients for whom the MMSE was available and for whom the MMSE was not available, using χ^2 for categorical variables, two-sample t-test for normally distributed variables and Mann-U Whitney test for non-parametric distributions.

We tested univariate associations between cognitive impairment and age, sex, baseline OHS, hypertension, diabetes, arm paralysis, leg paralysis, aphasia, neglect, sensory impairment, hemianopia. We retained significant variables ($p < 0.1$) from the univariate analysis in a multivariate logistic regression. We adjusted the analysis for clinical relevant factors such as history of depression and type of brain vascular event. Variables with $p < 0.05$ were considered independent predictors of outcomes.

Furthermore, we performed subgroup analysis in patients with defined diagnosis of ischaemic stroke and TIA. We accounted for the presence of potential interaction between

statistically significant stroke symptoms and functional status at baseline in our multivariate analysis.

Analysis was carried out by using SPSS for Windows (version 22.0; SPSS, Armonk NY, IBM Corp.).

Results

Data at baseline were available for 5453 patients, of whom 3476 (65%) were male, and the mean age ($\pm$ SD) was 62.5 ($\pm$ 12.5) years.

The median time from the onset of the qualifying event (stroke or TIA) to baseline assessment was 33 days (IQR=8-88).

The qualifying event was ischaemic stroke in 3970 (73%) of patients, TIA in around one fifth (1022, 19%), and haemorrhagic stroke in 461 (8%) (Fig.1). Assessment of cognitive status at baseline was not available for 540 (10%) patients whereas 29 (0.5%) had clinical diagnosis of dementia, and were therefore excluded from the analysis.

Table 1 shows baseline characteristics of study population. The majority of patients were functionally independent, with a median OHS of 1 (IQR=1-2). Hypertension was the most frequent cardiovascular risk factor (71%). About two thirds of patients had either arm or leg paralysis, whereas cortical symptoms such as neglect were less frequent (8%).

After one year, 129 (2.4%) of patients died, and after 3 years a total of 323 (5.9%) had died.

At one and three years follow up data on MMSE were available for 2270 (41.6%) and 1294 (23.7%) patients, respectively.

Patients for whom MMSE scores were available were older ($p<0.001$ at one and three years) and more likely to have less disability at baseline ($p<0.001$ at one and three years). They also had fewer neurological impairments such as aphasia (23% vs 29% at one year, $p<0.001$; 20%

vs 28% at three years, $p<0.001$) neglect (6% vs 9% at one and three years, $p<0.001$), arm paralysis (63% vs 73% at one year, $p<0.001$; 63% vs 71% at three years, $p<0.001$) and limb paralysis (53% vs 65% at one year, $p<0.001$; 53% vs 63% at three years, $p<0.001$) (Suppl. Tab.1 and Suppl. Tab.2).

At one year, 781 (34%) patients had $MMSE \leq 26$, at three years 391 (30%) had $MMSE \leq 26$.

After any brain vascular event age, female sex, stroke severity at baseline, diabetes were independently associated with poorer MMSE at both one and three years (Tab.2). Leg paralysis was also associated with $MMSE \leq 26$ at both time points (OR=1.62; 95% CI=1.20-2.20; OR=1.95; 95% CI=1.23-3.09 respectively). Arm paralysis was associated with poorer PSCI only at one year (OR=1.46; 95% CI=1.06-2.02). There was no interaction between limb paralysis and baseline functional status. Aphasia was associated with PSCI at three years (OR=1.56; 95% CI=1.15-2.11); there was also a significant interaction between presence of aphasia and OHS at baseline ($p=0.018$) (Suppl. Tab.3).

Subgroup analysis for ischaemic events (ischaemic strokes and TIA) confirmed age, female sex, stroke severity and diabetes as independently association with poorer cognitive performance at one and three years. Hypertension was also associated with cognitive impairment at three years. Leg paralysis remained associated with $MMSE \leq 26$ at both one and three years (OR=1.54; 95% CI=1.15-2.07; OR=1.82; 95% CI=1.16-2.85) (Tab.3), with no interaction with functional status at baseline. Aphasia was associated with cognitive impairment at one year (OR=1.35; 95% CI=1.06-1.72) and at three years (OR=1.78; 95% CI=1.26-2.53), and at three years there was evidence of interaction with functional status at baseline ($p=0.028$) (Suppl. Tab.3). Neglect, hemianopia and sensory impairment were not associated with cognitive impairment at one and three years in both stroke groups.

Discussion

We investigated the associations between baseline stroke symptoms and post stroke cognitive impairment defined as $MMSE \leq 26$. As defined by this cut-off, in our cohort around one third of patients with stroke in the long term had cognitive impairment. Age, female sex, stroke severity and history of diabetes were associated with PSCI at one and three years and in all study groups. Among stroke symptoms, paralysis in the lower limb at baseline was consistently associated with PSCI.

Our results regarding age, female sex, diabetes are in keeping with previous studies^{4,6} that demonstrated an increased risk of cognitive deficits after stroke. We found that hypertension was associated with PSCI only after three years and in the ischaemic stroke subgroup, suggesting a weak association. This result is in line with the aforementioned Pendlebury and Rothwell metanalysis⁶, which showed no association between hypertension and post-stroke dementia.

Interestingly, we found that leg paralysis at baseline appeared to be independently associated with cognitive impairment at both follow up time points. In addition, we observed a lack of interaction between leg paralysis and functional status at baseline. Gait problems may independently predict disability or death⁹ and risk of both cognitive impairment and dementia^{11,12}. In a population cohort study, hemiparetic gait has been associated both to vascular and non-vascular dementia¹². A recent prospective study found that gait impairment after mild stroke increased the risk of developing cognitive decline after two years¹³. Assuming leg paralysis as a surrogate of gait dysfunction, our results are in keeping with such association, and may support the link between leg dysfunction and cognitive impairment.

In our study, aphasia increased the risk of cognitive impairment one year after ischaemic stroke/TIA, although associations at three years were confounded by interaction with functional status at baseline. We acknowledge that aphasia could negatively affect the assessment of cognitive status with MMSE, which relies on the language ability of the patient¹⁴. Since language is a cognitive domain, language deficits represent a subset of cognitive impairment, therefore this result needs to be interpreted with caution.

We acknowledge shortcomings that may have biased our results. First, our data belong from a study population selected for clinical trials, it seems plausible a selection bias, and our results may not be entirely generalisable. Despite we had not access to a cognitive evaluation at baseline (i.e. evaluation of cognition during the acute stroke phase), which has been associated with post stroke cognitive impairment¹⁵, around 90% of our included patients had clinical evaluation regarding presence of dementia, and only a little percentage of them had clinical diagnosis of dementia. Again, the non-systematic assessment of cognitive function at follow up may have lead to an attrition bias. Although we found low mortality rates, our supplemental tables showed that selection likely favoured those with less neurological impairment. The higher rates of baseline symptoms such as paralysis or aphasia in patients without cognitive assessment at follow up seem to confirm that an attrition bias occurred. However, this fact may have underestimated rather than overestimate our results, reducing the rate of patients with cognitive impairment¹⁶.

Moreover, diagnosis of PSCI should be based on a comprehensive evaluation including a complete multi-domain neuropsychological battery. Use of a brief dementia screening tool, such as MMSE, is not a substitute for formal neuropsychological and clinical assessment.

However, in the context of multicentre clinical trials with many thousands of patients there

is a necessary trade-off between diagnostic detail and feasibility. MMSE is a reasonable tool for detection of post stroke dementia and is commonly used in practice as well as in research. Although a recent systematic review highlighted that MMSE is more specific than other screening tests for detection of cognitive impairment ⁹, the lack of sensitivity of the MMSE ≤ 26 cut-off may underestimate the real prevalence of cognitive impairment ^{17,18}. Together with attrition bias, it seems likely that the prevalence of cognitive impairment after stroke is higher than we reported. The major strength of our study is that our large sample size considerably increases the world data base, providing new data to perform future analysis. Our data are extracted from clinical trials datasets, which likely have less heterogeneity compared to prospective studies and clinical series. The aforementioned meta-analysis investigated 7511 patients with pooled data from a wide range of studies, our study provides a pool of 5453 patients enrolled in randomized clinical trials.

In conclusion, in our sample of patients with mild stroke, around 30-34% of patients experienced cognitive impairment between one and three years. We confirmed increasing age, female sex, stroke severity, history of diabetes as factors associated with PSCI. Among stroke features, leg paralysis may be involved in subsequent cognitive impairment in the long term follow up, suggesting that early detection of mobility impairment after stroke may help to identify patients at risk of cognitive impairment.

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Supplemental Table 1: characteristics of patients with available and unavailable one year MMSE.

Supplemental Table 2: characteristics of patients with available and unavailable three year MMSE.

Supplemental Table 3: stroke symptoms, functional status at baseline and their interaction with cognitive impairment.

Appendix:

*VISTA-Prevention Steering Committee

H-C. Diener (Chair), S. Davis, G. Hankey, K.R. Lees, B. Ovbiagele and C. Weir.

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Table 1. Characteristics of study population at baseline, one year and three years.

	Baseline N=5453	1 Year N=2270	3 years N=1294
Age, mean ($\pm$SD)	62.6 ($\pm$ 12.6)	64.1 ($\pm$ 11.9)	63.7 ($\pm$ 11.8)
Sex, male	3476 (64)	1515 (65)	848 (65)
OHS baseline, median (IQR)	1 (1-2)	1 (1-2)	1 (1-2)
Hypertension	3890 (71)	1664 (72)	925 (70)
Diabetes	1321 (24)	543 (23)	298 (22)
Ischaemic heart disease	928 (17)	397 (17)	201 (15)
Atrial fibrillation	420 (8)	179 (8)	98 (8)
Hypercholesterolemia	2299 (42)	1094 (47)	615 (47)
Smoker	1310 (24)	537 (23)	268 (20)
Depression	437 (8)	211 (9)	115 (9)
Arm paralysis	3753 (69)	1452 (63)	826 (63)
Leg paralysis	3310 (61)	1228 (53)	687 (52)
Aphasia/dysarthria	1438 (26)	541 (23)	261 (20)
Neglect	436 (8)	145 (6)	75 (6)
Sensory impairment	1780 (33)	732 (32)	462 (35)
Hemianopia	519 (10)	199 (9)	103 (8)

Values are numbers (%) unless otherwise stated. SD=standard deviation; OHS=Oxford Handicap Scale; IQR=Interquartile Range.

Table 2. Associations between baseline stroke symptoms and cognitive impairment (MMSE $\leq$ 26) in patients with every type of vascular event (ischaemic, TIA, haemorrhagic). Analysis adjusted for all the variables listed in the table. Only variables statistically significant in the unadjusted analysis were inserted in the multivariable analysis.

	All stroke subtypes			
	One year CI		Three years CI	
	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
Age	1.03 (1.02-1.03)	1.03 (1.02-1.04)	1.04 (1.03-1.05)	1.04 (1.03-1.06)
Sex, female	1.53 (1.28-1.84)	1.49 (1.22-1.80)	1.95 (1.53-2.50)	1.78 (1.37-2.31)
OHS baseline	1.71 (1.53-1.91)	1.38 (1.23-1.56)	1.53 (1.32-1.78)	1.30 (1.10-1.54)
Hypertension	1.35 (1.11-1.65)	1.09 (0.88-1.35)	1.68 (1.27-2.22)	1.25 (0.93-1.68)
Diabetes	1.74 (1.43-2.13)	1.57 (1.27-1.94)	2.14 (1.63-2.82)	1.86 (1.38-2.50)
Arm paralysis	1.93 (1.60-2.33)	1.46 (1.06-2.02)	1.41 (1.09-1.81)	0.97 (0.60-1.59)
Leg paralysis	2.10 (1.75-2.51)	1.62 (1.20-2.20)	1.74 (1.37-2.23)	1.95 (1.23-3.09)
Aphasia	1.24 (1.01-1.51)	1.24 (0.96-1.60)	1.63 (1.23-2.17)	1.67 (1.17-2.40)*
Neglect	1.13 (0.79-1.60)	-	0.97 (0.58-1.62)	-
Sensory impairment	0.90 (0.75-1.09)	-	0.82 (0.64-1.05)	-
Hemianopia	1.30 (0.96-1.76)	-	1.25 (0.81-1.91)	-

CI=Cognitive Impairment; OR=Odds Ratio; CI=Confidence Interval.

*p for interaction with functional status=0.018.

Table 3. Associations between baseline stroke symptoms and cognitive impairment (MMSE $\leq$ 26) in ischaemic events (ischaemic stroke and TIA). Analysis adjusted for all the variables listed in the table. Only variables statistically significant in the unadjusted analysis were inserted in the multivariable analysis.

	Ischemic stroke/TIA			
	One year CI		Three years CI	
	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
Age	1.03 (1.02-1.04)	1.03 (1.02-1.04)	1.04 (1.03-1.06)	1.04 (1.03-1.06)
Sex, female	1.72 (1.40-2.12)	1.57 (1.27-1.96)	2.09 (1.59-2.77)	1.86 (1.38-2.50)
OHS baseline	1.49 (1.33-1.68)	1.33 (1.18-1.51)	1.40 (1.20-1.64)	1.24 (1.04-1.48)
Hypertension	1.47 (1.17-1.85)	1.24 (0.97-1.58)	1.89 (1.37-2.62)	1.43 (1.01-2.03)
Diabetes	1.68 (1.35-2.10)	1.60 (1.27-2.02)	2.32 (1.71-3.13)	2.15 (1.56-2.97)
Arm paralysis	1.80 (1.44-2.25)	1.30 (0.96-1.77)	1.37 (1.02-1.84)	0.81 (0.51-1.29)
Leg paralysis	1.95 (1.58-2.40)	1.54 (1.15-2.07)	1.71 (1.29-2.27)	1.86 (1.19-2.92)
Aphasia	1.40 (1.12-1.76)	1.35 (1.06-1.72)	1.79 (1.30-2.48)	1.81 (1.28-2.57)*
Neglect	1.13 (0.78-1.65)	-	0.93 (0.54-1.61)	-
Sensory impairment	0.99 (0.81-1.23)	-	0.84 (0.63-1.11)	-
Hemianopia	1.27 (0.91-1.76)	-	1.36 (0.86-2.16)	-

CI=Cognitive impairment; OR=odds ratio; CI=Confidence Interval; OHS=Oxford Handicap Scale.

*p for interaction with functional status=0.028.

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