EDITORIAL

Volumes of intact gray matter outside the stroke predict gait performance

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Experimental[1] and clinical evidence support right hemisphere dominance for postural control, given its specialized role in constructing and updating spatial references.[2,3] As a prerequisite for walking, this right hemisphere dominance for postural control should also affect gait.[4] In this issue of *Neurology*®, Chen et al.[5] confirm this view and reveal that patients with a chronic right middle cerebral artery (MCA) infarct show slower and more asymmetrical gait as compared to those with a left MCA infarct and controls. Conclusions of this study are robust after controlling for possible confounding factors. Patients with a right (n = 19) or a left (n = 20) solitary infarct in the territory of the MCA showed similar poststroke duration (7.6 ± 6.0 years), functional independence, and infarct size precisely quantified with a 3T MRI. All were able to walk without assistance. Gait analysis was accurate and as naturalistic as possible, performed over 75 meters (indoor) at preferred speed, with plantar pressures measured by shoe insoles.

An asymmetrical loading on lower limbs, with much more weight on the ipsilesional foot than on the contralesional (paretic) foot, is a key postural behavior of stroke patients, related to spatial biases[3] as well as to sensorimotor deficits.[6] Up to now this asymmetry was quantified in erect stance using force platforms[3,6] or insole plantar pressure measurement.[7] The present study proposes a new way to quantify it: while walking, with temporal and spatial indices averaged over many steps. The asymmetry found was both temporal (single limb support time) and dynamic (plantar pressure).

There is increasing interest in analyzing correlates between the integrity of brain structures and motor recovery after stroke. Several studies showed that the recovery of skill abilities depended on the integrity of white matter, especially in corticospinal and interhemispheric tracts.[8–10] Chen et al.[5] analyzed the correlates between gray matter volumes and gait performance. Regional gray matter tissue volumes were calculated on high-resolution anatomic images into 5 anatomic regions outside the MCA territory (spared by the infarct), all presumed to be involved in gait control: superior parietal lobe, precuneus, caudate, putamen, and cerebellum. They were then normalized to intracranial cavity volume. In patients with right MCA infarct, those who walked faster were those with greater gray matter volume within the caudate ($R = 0.75$, $p < 0.001$) or the cerebellum ($R = 0.57$, $p = 0.02$). There was no correlation with gray matter volume in patients with left MCA infarct. These findings suggest the existence of a large network involved in gait control within the right hemisphere.

Gait requires an adapted body orientation with respect to gravity, an adapted stabilization of body segments and center of mass, the generation of a propulsion force throughout cycling movements, and secure navigation (surveillance of and adaptation to surroundings). This explains why many brain lesions may alter gait. Both the caudate and cerebellum are involved in locomotion control. The caudate is involved in movement accuracy and motor planning whereas the cerebellum is critical for intralimb and interlimb coordination of cyclic movements, along with a multisegmental regulation of body stabilization. The study by Chen et al. suggests that the inability of damaged brain areas to participate in gait control may be compensated by other intact parts of the neural circuits, here the caudate nucleus and the cerebellum. The findings also provide novel direct evidence of brain plasticity for gait control after stroke and support the idea that this plasticity might be facilitated by rehabilitation. Finally, from a rehabilitation perspective in stroke patients, looking at MRI must not be limited to lesion location and size: brain areas outside the stroke must be investigated for the potential of plasticity.

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Dominic Pérennou: drafting/revising the manuscript. Susan Hillier: drafting/revising the manuscript, analysis or interpretation of data.

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DISCLOSURE

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REFERENCES

1. Pérennou DA, Amblard B, Laassel el M, Pelissier J. Hemispheric asymmetry in the visual contribution to postural control in healthy adults. Neuroreport 1997;8:3137–3141.
2. Pérennou DA, Mazibrada G, Chauvineau V, et al. Lateropulsion, pushing and verticality perception in hemisphere stroke: a causal relationship? Brain 2008;131: 2401–2413.
3. Barra J, Oujamaa L, Chauvineau V, Rougier P, Pérennou D. Asymmetric standing posture after stroke is related to a biased egocentric coordinate system. Neurology 2009;72: 1582–1587.
4. Cassvan A, Ross PL, Dyer PR, Zane L. Lateralization in stroke syndromes as a factor in ambulation. Arch Phys Med Rehabil 1976;57:583–587.
5. Chen IH, Novak V, Manor B. Infarct hemisphere and noninfarcted brain volumes affect locomotor performance following stroke. Neurology 2014;82:828–834.
6. Genthon N, Rougier P, Gissot AS, Froger J, Pelissier J, Pérennou D. Contribution of each lower limb to upright standing in stroke patients. Stroke 2008;39:1793–1799.
7. Hillier S, Lai MS. Insole plantar pressure measurement during quiet stance post stroke. Top Stroke Rehabil 2009;16:189–195.
8. Borich MR, Mang C, Boyd LA. Both projection and commissural pathways are disrupted in individuals with chronic stroke: investigating microstructural white matter correlates of motor recovery. BMC Neurosci 2012;13:107.
9. Stinear CM, Barber PA, Smale PR, Coxon JP, Fleming MK, Byblow WD. Functional potential in chronic stroke patients depends on corticospinal tract integrity. Brain 2007;130:170–180.
10. Qiu M, Darling WG, Morecraft RJ, Ni CC, Rajendra J, Butler AJ. White matter integrity is a stronger predictor of motor function than BOLD response in patients with stroke. Neurorehabil Neural Repair 2011;25:275–284.