A Case of Balint Syndrome Due to Left Basal Ganglia Hemorrhagic Stroke:

Exploring the Pathogenesis Through Parietal Lobe Circuits

David R. Spiegel, MD[a,*]; Haley S. D'Souza, MD[a]; Kei-Lwun Yee, MD[a]; Natalia A. Kot, MD[a]; David M. Yuna, DO[a]; Anastasia M. Samaras, MD[a]; and Garrett F. Cook, MD[a]

Balint syndrome (BS) is a rare neurologic disorder associated with bilateral parieto-occipital damage that disrupts connections between the posterior visual association areas and the motor regions of the prefrontal cortex.[1] It typically consists of inaccurate reach responses to objects under visual guidance (optic ataxia [OAt]), disturbed organization of eye movements (ocular apraxia [OcA]), and an inability to perceive more than one object at a time (dorsal simultanagnosia [DS]). These symptoms are thought to develop, in part, from an impairment in visual attention, although OAt may also involve a visual proprioceptive deficit.[2,3] Additionally, basal ganglia (BG) participates in circuits involving visual attention vis-a-vis the fronto-parietal attention network,[4] oculomotor control,[5] and prehension movements.[6] Thus, lesions in BG potentially could present with DS, OcA, or OAt. We present a case of BS that followed left BG hemorrhagic stroke.

Case Report

The patient was a 76-year-old woman who came to the hospital after her husband noted she was "uncoordinated." Her vital signs were stable except for blood pressure of 223 mm Hg/152 mm Hg. Computed tomography (CT) of the brain revealed a left BG hemorrhagic infarct. The patient scored 16 on the National Institutes of Health Stroke Scale.[7] Pertinent positives included right-sided gaze palsy and hemiparesis.

Her past medical history was significant for hypertension, although she was not taking medications prior to admission. She had a remote history of nicotine and alcohol usage. Blood alcohol level and urine drug screen were negative. Her husband denied previous history of motor or cognitive deficits. Due to "restlessness," magnetic resonance imaging (MRI) was unobtainable until hospital day 30, but it corroborated CT findings and revealed additional hematoma encompassing left dorsal BG.

After the patient was reported removing her nasogastric tube, we were consulted on hospital day 35. Mental status examination was remarkable for dysarthria, although our patient was able to follow instructions without difficulty. When asked to track an object with her eyes, the patient had smooth saccadic movements to the left, but kept turning her head while trying to track objects to the right visual field. Her Mini-Mental State Examination[8] score was 21, but she had a negative assessment per the Confusion Assessment Method.[9] Given improvement in right hemiparesis, we evaluated our patient for BS.

When presented with the "cookie theft" picture,[10] our patient was able to identify individual items but could not describe the scene as a whole. She was shown a Navon figure (characters composed of smaller characters),[11] wherein she fixated on smaller letters and failed to report the larger letter *E* when prompted. Our patient was unable demonstrate voluntary right visual field saccades (left-sided saccades were unaffected). Nonetheless, 2 weeks later, difficulty producing voluntary saccades to verbal commands resolved. Finally, per the protocol of Borchers and colleagues,[12] misreaching behavior (she neither grasped the target in the first nor had other following movement) was observed using her contralesional arm for movements directed toward the contralesional/right visual half-field.

On the basis of this evaluation, we believed our patient's phenotype included DS, OcA, and OAt. For a review of BS in our patient, please see Figure 1.[13–19]

Discussion

In conclusion, similar to other neuropsychiatric disease, our patient's case of BS due to BG lesion can plausibly be viewed as a "circuit disorder."[20] BG is structurally represented within and between fronto-parietal attention (posterior parietal cortex [PPC]/dorsal frontal cortex including frontal eye fields), oculomotor (frontal/parietal oculomotor cortex), and dorsomedial reach pathway (primary motor cortex/supplementary motor area and PPC/superior parietal lobule) circuits.[16,18,21–23] While BS has overwhelmingly been associated with parieto-occipital pathology, different lesion combinations have been described in the literature.[24,25] Thus, per our case, a BG lesion within or between these 3 parietal lobe circuits could present with the phenotype of BS, ie, DS, OcA, and OAt, respectively, yet without the classical bilateral parieto-occipital lesions that typically produce BS.

[a]Department of Psychiatry and Behavioral Sciences, Eastern Virginia Medical School, Norfolk, Virginia

*Corresponding author: David R. Spiegel, MD, Department of Psychiatry and Behavior Sciences, Eastern Virginia Medical School, 825 Fairfax Ave, Norfolk, VA 23507 (spiegedr@evms.edu).

Prim Care Companion CNS Disord 2021;23(2):20l02742

To cite: Spiegel DR, D'Souza HS, Yee KL, et al. A case of Balint syndrome due to left basal ganglia hemorrhagic stroke: exploring the pathogenesis through parietal lobe circuits. *Prim Care Companion CNS Disord.* 2021;23(2):20l02742.

To share: https://doi.org/10.4088/PCC.20l02742

Figure 1. Proposed Pathophysiology of Balint Syndrome Due to Basal Ganglia Hemorrhage[a]

ABBREVIATIONS

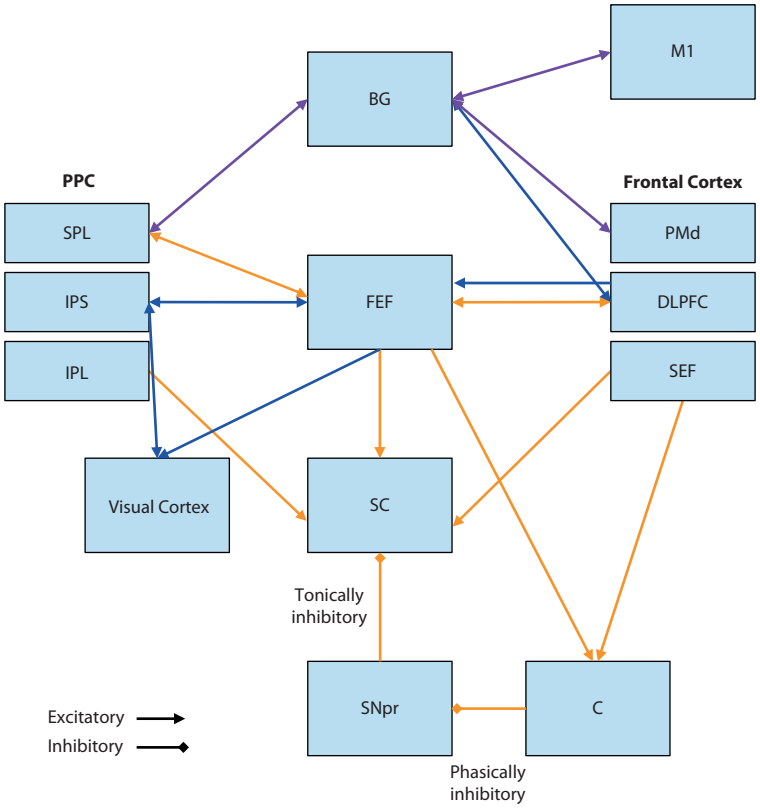
BG = basal ganglia, BS = Balint syndrome, C = caudate, dFPN = dorsal fronto-parietal network, DLPFC = dorsolateral prefrontal cortex, FEF = frontal eye field, IPL = inferior parietal lobule, IPS = intraparietal sulcus, M1 = primary motor cortex, PMd = dorsal premotor cortex, PPC = posterior parietal cortex, SC = superior colliculus, SEF = supplementary eye field, SNpr = substantia nigra pars reticulata, SPL = superior parietal lobule.

BS classically develops from bilateral lesions in PPC.

1. PPC is divided by IPS into SPL and IPL.
2. The anatomical definition of the dFPN includes SPL and IPS, representing the parietal node of the dFPN, while PMd comprises dFPN anterior node.
3. The FEF is located at the junction between the superior frontal sulcus and the precentral sulcus.
4. BG is known to participate in 5 parallel but largely convergent loops related to the major cortical areas of the brain, including parietal and frontal cortex.

SACCADE GENERATION AND OCULAR APRAXIA

5. FEF reportedly generates voluntary saccades. The projection of PEF to SC triggers reflexive visually guided/express saccades. Saccade-related neurons in the caudate receive inputs from the FEF, SEF, and DLPFC. Caudate projects to the SNpr. Neurons in the SNpr may influence both target selection and saccade initiation. The SNpr, in turn, sends inhibitory projections to SC.
6. A simplified view of the BG pathway is that it is composed of 2 serial, inhibitory links: caudate-nigral, which is only phasically active, and nigro-collicular, which is tonically active.
7. Commands to initiate voluntary saccades leads to FEF activating caudate-nigral neurons to fire. Nigro-collicular inhibition is subsequently removed and SC is able to activate a saccade. Thus, if BG function is impaired, the "double disinhibition" between caudate-nigral and nigro-collicular tracts may not occur and voluntary saccades are prevented. This could potentially result (for our patient) in developing ocular apraxia.



VISUAL ATTENTION AND SIMULTANAGNOSIA

8. Fronto-parietal attention network designates dorsal brain regions that are often activated concurrently when individuals are engaged in tasks requiring the shifting of attention in space. These regions comprise IPS and SPL (in PPC) and premotor and prefrontal cortex (including FEF).
9. Dorsal attention network linking IPS with FEF is mainly responsible for voluntary orienting of attention.
10. Successful integration of sensory signals with behavioral goals entails a constant exchange of information between the FPAN, the prefrontal cortex, and sensory areas.
11. BG has been reported to play an important role in filtering out irrelevant information. Stimulus information that is to be reinforced may degrade over time due to increased ambient noise from the visual world.
12. Simultanagnosia can be explained by impairment of visual working memory. That is, instead of global precedence occurring (human visual system normally resolves the global properties of a visual scene first and is able to categorize scenes rapidly, based solely on their gist), BG impairment allows distractors to interfere with a visual scene and thus only parts of a visual scene are identified.

REACH/GRASP AND OPTIC ATAXIA

13. Dual Visuomotor Channel Theory. Manual prehension (the act of reaching to grasp an object) consists of two temporally integrated movements, each subserved by distinct visuomotor pathways in occipito-parieto-frontal cortex.
14. The "reach" is mediated by a dorsomedial pathway and transports the hand in relation to the target's extrinsic properties (ie, location and orientation).
15. The "grasp" is mediated by a dorsolateral pathway and opens, preshapes, and closes the hand in relation to the target's intrinsic properties (ie, size and shape).
16. The dorsomedial "reach pathway" projects through the SPL via the parietal reach region, which includes the superior parieto-occipital cortex, medial IPS, and anterior precuneus. It then projects to PMd and finally to M1, which ultimately projects to BG.
17. In reach and grasp movements, the brain must analyze visual input about the object and the environment; analyze proprioceptive input from the limb, head, and eyes; update its representations in relation to dynamic changes of the environment and the arm; and issue appropriate and precisely timed motor commands.
18. Both PPC and BG are critical for on-line visuomotor control, particularly in response to perturbations of either a target to be reached or an object to be grasped.
19. The anterior IPS is a cortical region involved in the integration of a target goal with an emerging action plan during visually guided reach-to-grasp tasks. When this region is temporarily disabled, corrective responses during reach to perturbed objects are disrupted. Additionally, anterior IPS has been shown to receive significant inputs from BG. Dysfunction of BG PPC circuits may result in inappropriate input to aIPS for detecting and/or correcting for online disruptions to reach or grasp.
20. Online monitoring of arm-hand movement can be affected by BG lesions, presenting as symptoms of optic ataxia. Alternatively, in a more general description, lesions in BG could result in upstream impairment in fronto-parietal circuits and present as optic ataxia.

[a]Based on references 13–19.

Published online: April 1, 2021.

Potential conflicts of interest: **Dr Spiegel** is in the Speaker's Bureau for Allergen, Alkermers, Otsuka, and IntraCellular Pharmaceuticals, but has no conflict of interest in preparation of this manuscript. **Drs D'Souza**, **Yee**, **Kot**, **Yuna**, **Samaras**, and **Cook** have no disclaimer/conflict of interest to report.

Funding/support: None.

Patient consent: The patient (and husband) did give verbal consent to publish the manuscript, and we have de-identified her to protect anonymity.

REFERENCES

1. Drane DL, Lee GP, Huthwaite JS, et al. Development of a partial Balint's syndrome in a congenitally deaf patient presenting as pseudo-aphasia. *Clin Neuropsychol*. 2009;23(4):715–728.
2. Zgaljardic DJ, Yancy S, Levinson J, et al. Balint's syndrome and post-acute brain injury rehabilitation: a case report. *Brain Inj*. 2011;25(9):909–917.
3. Jacobs DA, Liu GT, Nelson PT, et al. Primary central nervous system angiitis, amyloid angiopathy, and Alzheimer's pathology presenting with Balint's syndrome. *Surv Ophthalmol*. 2004;49(4):454–459.
4. Henry MJ, Herrmann B, Obleser J. Selective attention to temporal features on nested time scales. *Cereb Cortex*. 2015;25(2):450–459.
5. Lanciego JL, Luquin N, Obeso JA. Functional neuroanatomy of the basal ganglia. *Cold Spring Harb Perspect Med*. 2012;2(12):a009621.
6. Grafton ST. The cognitive neuroscience of prehension: recent developments. *Exp Brain Res*. 2010;204(4):475–491.
7. NIH Stroke Scale. National Institute of Neurological Disorders and Stroke. October 1, 2003. https://www.ninds.nih.gov/sites/default/files/nih_stroke_scale_508c.pdf
8. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189–198.
9. Inouye SK, van Dyck CH, Alessi CA, et al. Clarifying confusion: the confusion assessment method: a new method for detection of delirium. *Ann Intern Med*. 1990;113(12):941–948.
10. Goodglass H, Kaplan E. *The Assessment of Aphasia and Related Disorders*. Philadelphia, PA: Lea & Febiger; 1983.
11. Navon D. Forest before trees: the precedence of global features in visual perception. *Cognit Psychol*. 1977;9(3):353–383.
12. Borchers S, Müller L, Synofzik M, et al. Guidelines and quality measures for the diagnosis of optic ataxia. *Front Hum Neurosci*. 2013;7:324.
13. Bisley JW, Goldberg ME. Attention, intention, and priority in the parietal lobe. *Annu Rev Neurosci*. 2010;33(1):1–21.
14. Ptak R, Schnider A, Fellrath J. The dorsal frontoparietal network: a core system for emulated action. *Trends Cogn Sci*. 2017;21(8):589–599.
15. Su CY, Chen HM, Kwan AL, et al. Neuropsychological impairment after hemorrhagic stroke in basal ganglia. *Arch Clin Neuropsychol*. 2007;22(4):465–474.
16. Leigh RJ, Kennard C. Using saccades as a research tool in the clinical neurosciences. *Brain*. 2004;127(pt 3):460–477.
17. Ptak R. The frontoparietal attention network of the human brain: action, saliency, and a priority map of the environment. *Neuroscientist*. 2012;18(5):502–515.
18. Voytek B, Knight RT. Prefrontal cortex and basal ganglia contributions to visual working memory. *Proc Natl Acad Sci U S A*. 2010;107(42):18167–18172.
19. Thomas C, Kveraga K, Huberle E, et al. Enabling global processing in simultanagnosia by psychophysical biasing of visual pathways. *Brain*. 2012;135(Pt 5):1578–1585.
20. DeLong M, Wichmann T. Changing views of basal ganglia circuits and circuit disorders. *Clin EEG Neurosci*. 2010;41(2):61–67.
21. Karl JM, Whishaw IQ. Different evolutionary origins for the reach and the grasp: an explanation for dual visuomotor channels in primate parietofrontal cortex. *Front Neurol*. 2013;4:208.
22. Inouchi M, Matsumoto R, Taki J, et al. Role of posterior parietal cortex in reaching movements in humans: clinical implication for 'optic ataxia.' *Clin Neurophysiol*. 2013;124(11):2230–2241.
23. Lukos JR, Snider J, Hernandez ME, et al. Parkinson's disease patients show impaired corrective grasp control and eye-hand coupling when reaching to grasp virtual objects. *Neuroscience*. 2013;254:205–221.
24. Chechlacz M, Humphreys GW. The enigma of Bálint's syndrome: neural substrates and cognitive deficits. *Front Hum Neurosci*. 2014;8:123.
25. Rizzo M, Vecera SP. Psychoanatomical substrates of Bálint's syndrome. *J Neurol Neurosurg Psychiatry*. 2002;72(2):162–178.