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Review

Left Gaze Bias with Left Sensory Hemineglect Syndrome: Hallucinations and Hemispacial Neglect Following Right Middle Cerebral Artery Cerebrovascular Accident

Benjamin B DeVore¹, Ransom W Campbell¹, Patti Kelly Harrison¹ and David W Harrison^{1*}¹*Behavioral Neuroscience Laboratory, Virginia Polytechnic Institute & State University, Blacksburg, Virginia***Abstract****Introduction**

Lesions within the right middle cerebral artery distribution commonly result in one or another variant of left hemineglect syndrome with sensory or attention deficits derived from damage within the posterior branches serving occipital, temporal, and parietal brain regions. Motor or intentional deficits within left hemispace have been commonly derived from damage within the anterior branches of the right middle cerebral artery.

Method

MRI and neurological workup of an 81-year-old, right-handed female were followed by occupational, physical, and speech therapies with neurobehavioral and neurocognitive assessment by the clinical neuropsychologist.

Results

Case study evidence was provided wherein the patient demonstrated left sided rapid eye movements and emotional apprehension or fear with preoccupation for left hemispace concurrent with left hemineglect syndrome.

Conclusion

Spurious activation of damaged right posterior brain regions processing sympathetic drive, fearful apprehension or panic, and sensory-perceptual analyses of visual, auditory, and somatosensory modalities may yield hallucinated content. Moreover, such events may correspond with the specializations of these brain regions, wherein the modality specific content joins with the affective valence and autonomic specializations of these regions. Further, left sided preoccupation with panic symptoms concurrent with left hemineglect syndrome may be suggestive of hallucinated content where cautions may be implemented for left sided sensory oscillations and where supportive emotional therapies might be considered.

Keywords : Left Hemineglect; Hallucinations; Panic; Fear; Autonomic Nervous System; Sympathetic Nervous System; Emotion; Stroke; CVA; Right Brain; Brain Asymmetry

Introduction

Prevalence estimates have placed the incidence of cerebrovascular accident (CVA) at approximately 10 per 100,000 per year, with the total number of individuals suffering from either acute ischemic or hemorrhagic CVA at around 700,000 per year in the United States [1]. As a result, CVA is the leading cause of long-term disability and the third leading cause of death in the United States [1]. For those who survive the initial or recurrent CVA, inpatient rehabilitation is common and requires close evaluation with continued follow-up care.

Generally, in acute settings, the presence of neuropsychological dysfunction arising from left cerebral damage is readily apparent with patients who present as variably apraxic or aphasic and often exhibiting notable deficits in logical linguistic or propositional speech [2]. The same is not always the case for those patients who have suffered from significant right hemisphere damage. The differences in the presentation of patients following left or right cerebral injury is largely due to the competing roles and functional specializations of the cerebral hemispheres.

Patients often do not characteristically exhibit deficits following right hemisphere damage because the dysfunction results from damage to systems that are involved in the outward expression of aberrant neurological processes. Thus, a patient's loss of self-awareness, as in

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the case of posterior right cerebral damage, leaves him or her unaware that anything is wrong in the first place and therefore makes it difficult for clinicians, without the specialized training, to detect the functional clinical correlates underlying these right cerebral syndromes (see 3). Often this manifests in patients who end up in acute inpatient rehabilitation following a stroke with the therapists (e.g. occupational, physical, etc.) finding their rehabilitation efforts to be difficult to implement or ineffective. The disorders manifesting from right hemisphere damage particularly warrant the consult of the clinical neuropsychologist who is acutely qualified to discern the nature of the patient's neurobehavioral status. In the case of right hemisphere strokes, patients often present with deficits in awareness of deficits, spatial relations, and emotional processing (e.g., nonpropositional speech deficits or aprosodia).

The term unilateral neglect has come to encompass three primary subtypes of neglect disorders: spatial neglect, sensory (attentional) neglect, and motor (intentional) neglect (4; see 3). In the case of a sensory (inattention) neglect, patients fail to respond to stimuli presented contralateral to a lesion, that does not involve deafferentation or focal cortical sensory damage [3,4,5]. This type of neglect may also be represented in extinction to bilateral simultaneous stimulation in which patients fail to acknowledge a stimulus presented contralateral to the lesion when it is simultaneously applied to the ipsilesional side [4,5]. A central characteristic of sensory neglect is that it may occur in either the visual, tactile, or auditory modalities, generally elicited through careful testing during the neurobehavioral examination.

The description of hemispatial neglect is one in which a patient fails to report, respond or orient to, explore, or otherwise direct attention toward the visual or body space contralateral to a lesion [6,7,8,4,9]. This loss of ability is not due to hemisensory deficits or deafferentation, per se [9]. Three spatial frames exist for the individual neglect patient: egocentric (with reference to the body) space, peripersonal (physical space around the body) space, and allocentric (extrapersonal-with reference to objects outside the body) space [7]. However, the egocentric spatial frame has largely encompassed peripersonal space with allocentric space specific only to the extrapersonal spatial domain. As such, patients may neglect objects within the body space, within hand-reach, or within extrapersonal space. Within the extrapersonal spatial frame, patients may neglect the left half of an object regardless of its position in visual space (i.e. an object-centered deficit).

Awareness deficits are common in right hemisphere stroke often presenting as anosognosia, or the lack of awareness of deficit [10]. Anosognosia generally presents as patient unawareness or explicit denial of a prominent deficit (e.g. paralysis of the left upper extremity). The high frequency with which anosognosia presents along with hemispatial neglect often make it particularly difficult to both clinically dissociate the two disorders and to determine the underlying anatomic lesion patterns that might distinguish these disorders as separate entities. Clinically,

they often appear as potentially a unified construct for brain pathology in this area. Though considerable evidence has implicated specific anatomic regions in the production of the various neglect disorders, the neuropathology of anosognosia is considerably less clear. Dissociation is made more complicated by the fact that spatial neglect is theoretically a form of unawareness of portions of coordinate space. Thus, some have come to consider the disorders part of the same larger construct. In the case of hemispatial neglect without anosognosia, the patient neglects the left half of space, but when the clinician directs the patient's attention to the neglected side or brings the paralyzed extremity into the non-neglected side of space, the patient will "become aware" that there is a deficit and be able to cogently discuss this. In the case of neglect with anosognosia, the patient will fail to recognize there is a deficit even when attention is redirected to the neglected side of space or when the limb is moved into the ipsilesional hemisphere.

The most reliable neuropathological findings have implicated the right inferior parietal, posterior-superior temporal lobe in the production of hemispatial neglect [6,11,12,13,14,4,15,16]. Sensory neglect and extinction disorders likely involve more focal areas of the parietal-occipital-temporal junction, whereas lesions involving posterior occipital association areas tend not to produce neglect but rather visual agnosias and perceptual disturbances [12,4,17,18]. As previously mentioned, the locus of lesion in anosognosia is not as clear, but reliable data have implicated the role of extensive fronto-parietal regions in the right hemisphere.

Formesthasias or hallucinations of forms, resulting from right occipital-parietal damage may also be difficult to diagnose with the primary clue derived from an agitated or combative state with fearful apprehension, panic features, and elevated sympathetic drive (right brain). Given the right hemisphere's specialization for intense and generally negatively valenced emotions [19], formesthasias that result from right occipital damage tend to manifest as frightening or ominous presentations. These visual hallucinations may take on the various forms associated with the beliefs or experiences of the patient. If the primary projection area of a given sensory modality remains intact post brain injury, but the neural pathways connected to the higher cortical association areas are severed, sensory areas (such as the primary visual cortex) may become disinhibited resulting in cortically driven formesthasia[3]. Formesthasias can be visual, auditory, and somatosensory in nature. Interestingly, auditory formesthasias resulting from right temporal- parietal damage not only take on an ominous, incongruous form with coercive themes or the patient's belief that he or she must not tell anyone they are seeing or hearing the forms. Theoretically, the experience of these negatively prosodic sounds are due to the right hemisphere's preferential role in processing both prosody and extra-personal space with an overall tendency to avoid or distrust other people while processing the potential of external threats [3]. The presentation of such symptoms can be overly confusing to the therapist due to the increased attention the patient may

pay to the left visual hemispace with signs of increased anxiety or distress, while denying seeing or hearing anything.

The current report presents the case of a patient with left hemispatial neglect with anosognosia and left visual formesthesias following acute right middle cerebral artery CVA. The patient was transferred to the rehabilitation unit in a major medical center post CVA and was an active participant in a multidisciplinary team approach to treating her brain disorder. Both her treatment and assessments resulted from the efforts of various therapists including physical therapists, occupational therapists, speech therapists and neuropsychologists. The current case report relied on physician reports, neuroradiological findings via magnetic resonance imaging, behavioral observations and feedback from the patient's multidisciplinary team, and the neuropsychological evaluation, which combined both the standardized test battery and neurobehavioral syndrome analysis administered by a clinical neuropsychologist. Combined, the information presented in the current case study demonstrates the importance of utilizing a multidisciplinary approach for exceptional patient assessment and care.

Patient Information and History

The patient is a retired 81-year-old, right-handed, African-American female who presented to the medical center with acute CVA. Following emergency care, she was assessed by neuropsychological evaluation and treated by a multidisciplinary team in the rehabilitation unit of a major medical center. MRI scans of her head were conducted and interpreted to reveal a post hemorrhagic conversion of the right posterior middle cerebral artery infarct with mass effect on the right parietal and right occipital regions (see Figures 1 and 2). Overall analysis of the scans indicated a right middle cerebral artery CVA with focus in the right parietal, temporal, and posterior frontal regions and a petechial hemorrhage with mass effect. Her medical history is remarkable for atrial fibrillation, anemia,

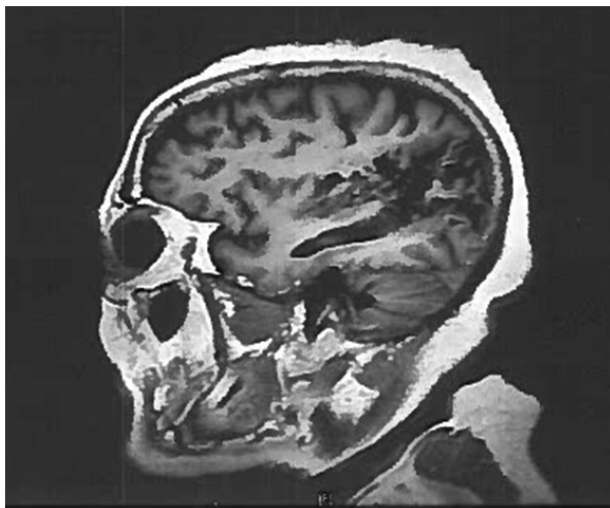


Figure 1: Sagittal section from the head MRI showing lesion location within the right posterior middle cerebral arterial distribution.

hyponatremia, hypertension, asthma, hyperlipidemia, leukopenia, purulent, bronchitis, and left atelectasis.

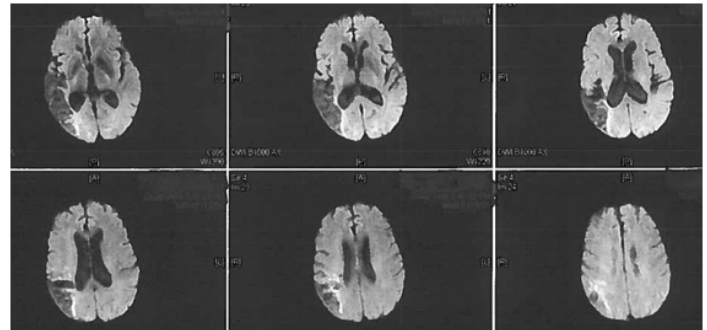


Figure 2: Horizontal sections from the head MRI showing lesion locations within the right posterior middle cerebral arterial distribution.

Review of Physician Notes Documented Upon Admission

Initial reports from the attending physician indicated the patient was "pleasant" and alert upon admission to the medical center for the acute CVA, but became lethargic and confused upon discharge to inpatient rehabilitation 4 days later. A subsequent MRI revealed the development of a petechial hemorrhagic conversion of the previous infarct within the right MCA distribution. The patient was retransferred to the rehabilitation unit where she was monitored for further development of petechial hemorrhagic conversion of the MCA infarct. Final CT scans completed two weeks after the patient was admitted to the medical center indicated improvement in the hemorrhagic conversion with stable white matter edema. Electroencephalogram was not completed.

Upon readmission to the rehabilitation unit, the multidisciplinary team treating the patient made various observations of left hemineglect. These observations included instances of left hemispatial neglect (including running into objects), diminished insight into her deficits, left sensory neglect, and left spatial agraphia. However, it was noted the patient could attend to the left hemispace with directed attention. Her suspected left spatial neglect was relevant enough to warrant reassignment to a room with the entrance in the patient's right visual field as to diminish the relative distress she experienced when the medical center staffs enter the room with a left sided entrance.

Neuropsychological Evaluation

Several facets of the patient's presentation led to evaluations for left hemineglect with a visual gaze bias for visual formesthesias (hallucination) in the left hemispace. In addition to physician and therapist note review, the extant literature on the distribution and the mass effect of the infarct in the right MCA on the right parietal and right occipital regions was suggestive of anosognosia, left-hemispatial neglect, and distressing formesthesias in the left visual field as a right brain disorder (see 3). These symptoms were clinically indicated as rule-outs for neuropsychological assessments administered assessing potential damage to these regions.

While the patient made statements of concern for sensation in the left hemispace, her continued perceived neglect (dropping objects from her left hand without awareness and halting action at midline) of the left hemispace appeared to indicate some level of anosognosia.

Evidence provided by the attending neuropsychologist, occupational therapist, speech therapist, and physical therapist on the multidisciplinary team further support the implications of left spatial neglect with an intentional/volitional bias and preoccupation to the left hemispace. The speech therapist noted discontinuation of written tasks across the midline into left spatial orientation, as well as difficulty attending to objects in the lower visual field. Further notation included difficulty looking to the left to command and asomatagnosia. Occupational and physical therapists noted difficulty traveling towards the left hemispace and difficulty finding objects on the left side. The patient also demonstrated decreased processing speed when presented with stimuli from the left. Despite these reported deficits, it was also observed that the patient had a tendency to move her gaze into her left field of vision reflecting integrity of the right frontal eye field and preoccupation with the hallucinated content at the left hemispace. These various behaviors, including her reported medical condition, led to a specific referral to the neuropsychologist.

Standardized Assessment

Standardized testing for neuropsychological and mood-related difficulties was conducted using the Mini-Mental Status Exam, 2nd edition (MMSE-2; 20); the Geriatric Depression Scale (GDS; 21); and the Disability Rating Scale (DRS-2). The patient performed in the “questionably significant” range on the MMSE-2 (27/30), demonstrating only deficits in the verbal recall task and the design construction task. On the design construction task, she was unable to connect the two consequent designs despite multiple attempts to do so. Administration of the GDS implicated mild depressive symptoms (16/30) with the patient endorsing items such as “Do you feel that your life is empty?” and “Do you often feel helpless?”

The DRS-2, which assesses neuropsychological functioning across various neurocognitive domains (attention, initiation/perseveration, construction, conceptualization, and memory) indicated overall neuropsychological functioning in the moderately impaired range (Total Score = 118, 3-5 percentile, impaired range compared to same aged peers). She demonstrated relative strengths in attention (Score = 35, 41-59 percentile) and conceptualization (Score = 36, 41-59 percentile), with memory (25, 90-94 percentile) being her strongest area. Conversely, her initiation/perseveration (Score = 20, <1 percentile) and construction (Score = 2, <1 percentile) were severely impaired. Further evidence for her deficits was implicated specifically by the constructional tasks with her drawings halting towards the left with left sided omission errors (see Figure 3).

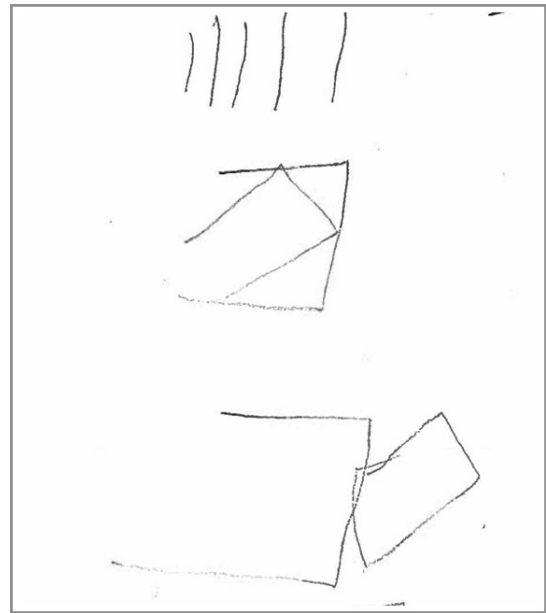


Figure 3: Behavioral samples showing left-sided omission errors and spatial distortions using figure copy tasks from the DRS-2.

Neurobehavioral Syndrome Analysis

The neuropsychological evaluation provided evidence for left hemineglect syndrome in the presence of an intentional or volitional gaze bias to the left hemifield/hemispace secondary to hallucinated content or formesthesias. Sensory examination yielded visual extinction in the left upper and lower quadrants, as well as left hemianesthesia with omission errors upon tactile confrontation with light tapping stimuli at the left hemibody. Examination of simple motor tasks indicated left upper extremity paresis, unless the patient attended directly to the action, indicating partial sensory neglect as opposed to a loss of motor function. While her speech appeared to be intact, the patient confirmed she has to slow down her speaking or else she will stumble over her words, indicating potential dysarthria. The patient also showed a tendency for listing to the left. Observations were also remarkable for left visual gaze and attention bias to the left visual field associated with multimodal left sided hallucination accompanied by fearful apprehension or fearful rumination. Left sided tactile hallucinations were also reported, experienced predominantly at the left hand. Olfactory hallucinations were reported with the patient claiming she smelled garlic consistently throughout the day.

The reported left sided visual and auditory hallucinations included “spooky faces” and people speaking evil about her. These hallucinations occur with spatial delusions conveying intentions to drag her away from her family into another world. The patient confirmed the entity does not want her to talk to others or to acknowledge its’ presence to others. These symptoms are consistent with the MRI scan of her head, indicating a likely disconnection syndrome from fearful/negative emotional analyzers across the corpus callosum to the ventral language pathways. Her left hemispatial preoccupation included rapid eye movement and leftward

gaze. It was further noted, the patient experiences sun downing with fearful apprehension during the p.m. hours and with darkness or dim ambient-lighting levels. Finally, it was noted she has dressing apraxia and constructional apraxia consistent as clinical correlates for her posterior right middle cerebral artery CVA.

In order to further determine the degree of insight into neglect-related deficits, a multiple reporter strategy was employed using the Catherine Bergego Scale (CBS; see 22; 23). The CBS is composed of 10-items referenced to a 4 point rating scale, with 0 being no neglect and 3 being severe neglect. The CBS is designed to be completed by an independent observer of patient behavior, as well as a self-report assessment to determine the degree of deficit awareness. The assessment asks questions related to neglect of left-hemibody objects and neglect for objects located in extrapersonal space. Example questions include "Forgets about a part of the left side of the body" and "May collide with people or objects on the left side." The CBS was completed independently by the patients primary speech pathology and occupational therapist involved in direct care for the patient. The therapists rated the patient's left hemineglect behaviors at 16 out of 30. The patient was then administered the same assessment as a comparator to the therapists report. The patient endorsed items resulting in a total score of 10 out of 30, specifically endorsing colliding with people or objects on the left side and forgetting about parts of her body on the left side. Given the relative collusion of the specific items on the two reports, the patient appears to demonstrate some degree of anosognosia with demonstrable left hemineglect syndrome.

Finally, the patient was administered the Draw-a Clock Test (Figure 4), where she was asked to draw a clock showing the time 2:55, to further determine left hemispatial constructional abilities. She demonstrated clearly evident constructional deficits within the left spatial regions, neglecting numbers and clock arm placement lateral to the left of the clock midline, despite being able to accurately draw the right side of the clock. Her inability to draw the left side of the clock was accompanied by observed confusion and repeated attempts to construct the drawing to the left of the midline. Her perseveration in the task provided further evidence for the presence of object-centered left hemispatial neglect.

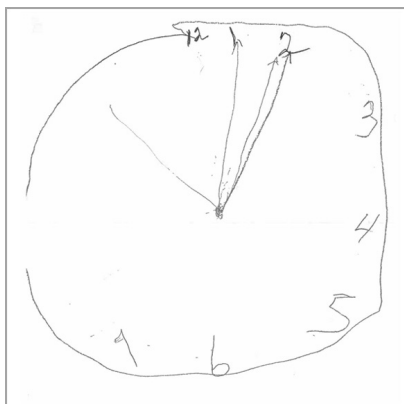


Figure 4: Behavioral sample using the Draw a Clock test.

Discussion

The clinical evaluation and primary findings of this report support diagnoses of a left hemispatial neglect with a waxing and waning presentation due to arousal deficits. Additionally, there was evidence of symptom neglect, constructional apraxia, dressing apraxia, and left visual and auditory hallucinations. The interdisciplinary evaluations, neuropsychological assessment, and resulting diagnoses are further supported by the extant literature on the neurological impact of a right middle cerebral artery CVA and the potential resulting damage to the right occipital, temporal, and parietal functions (contralaterally regulating the left hemibody and left hemispace attention; see 3).

With regard to the left hemispatial neglect without anosognosia, the neuropsychological evaluation and interdisciplinary reports provided significant evidence for the patient's lack of general attention and insight towards left hemispace that included left body part neglect, left constructional apraxia, and object neglect in the left hemifield. This may be indicative of the extent to which the patient's expression of spatial neglect was specific to objects and the various and often-heterogeneous presentations of unilateral neglect as a syndrome. Patients may experience hemispatial neglect in egocentric (with reference to the body space) and allocentric (with reference to objects outside the body space) spatial frames [4,9]. Additionally, with regard to the allocentric spatial frame, an individual may further demonstrate deficits that indicate a broad loss of spatial awareness (loss of much of the left half of space) or more specific object-centered deficits, as in the case of the current patient [24,25,26,9]. Thus, our patient experienced an allocentric deficit due to object-centered left hemispatial neglect. Her impairment on the clock-drawing test is a classic demonstration of this syndrome and also demonstrates her constructional apraxia.

Despite the presence of left hemispatial neglect, there was evidence of a gaze bias with apprehensive affect presentation towards the left visual field. The preservation of egocentric and allocentric spatial frames beyond objects may explain why she was able to experience visual release hallucinations in the left visual field. Through the neuropsychological analysis, the patient confirmed experiencing visual formesthasias or hallucinations in the left hemifield. This presentation was initially confusing to attending therapists and could easily be interpreted as malingering given the patient's inability to attend to stimuli in the left hemispace while maintaining a focused gaze to the left.

The proposed functional neural system impacted by the patient's CVA included the parietal-occipital-temporal junction (POT area) in the right hemisphere. This region has been found to be integral in perception processing as the interconnection of secondary association areas [27,28,29]. Damage to this area has been shown to result in symptom expressions similar to those presented in the current case study. The multitude of right hemisphere syndrome presentations resulting from

lesions to heteromodal association cortex has been well documented [3,2]. Disorders of space, emotion, and disruptions of self-awareness are not uncommon. Additionally, individuals may experience a multitude of deficits related visuospatial perception, topographical and geographical orientation, and the various ways in which the right hemisphere has been found to contribute to left hemisphere functions (constructional apraxia, neglect dysgraphia, spatial agraphia, etc.) making localized damage particularly complicated [30]. Consequent unbridling of specific caudally located right hemisphere areas has been theorized to produce polyvoltage fluctuations resulting in sensory experiences driven by that specific cortex. In the current case, these voltage fluctuations appear to be localized in both the occipital and temporal lobes, resulting in the cortically driven visual and auditory hallucinations.

The current case study presents a unique right brain syndrome implicating the confluence of deficits in spatial awareness systems specific to left allocentric space with co-occurring left lateralized multimodal hallucinations. The presence of multimodal hallucinations and specifically visual hallucinations is rare with spatial neglect and thus this case provides a unique documentation of these dysfunctions. Via a comprehensive neuropsychological evaluation the patient's syndrome presentation was determined and recommendation for rehabilitation provided. Given the need for continued understanding of the impact of neurological damage resulting in complex syndrome presentations, this case is provided as support for the continued need to implement increased multidisciplinary assessment and treatment to neurological disorders. By integrating neuropsychological evaluations into medically accepted therapeutic interventions (such as physical therapy and occupational therapy) it is possible to obtain a more complete understanding the potential neural underpinnings of seemingly disconnected symptoms.

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