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Effects of visual impairment after acute stroke on activities of daily living

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Effects of visual impairment after acute stroke on activities of daily living

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Abstract

Objective: In stroke patients with visual impairment, it is unclear which activities of daily living (ADL) are affected or how they are affected. This study aimed to determine the effect of the type and frequency of visual impairments on ADL in acute stroke patients.

Methods: We interviewed stroke patients without severe movement disorder, aphasia, general inattention, or hemispatial neglect who were admitted to our hospital between September 2018 and May 2020 for lesions in the cortical and subcortical white matter posterior to the central sulcus. The patients were asked via a questionnaire whether they had ADL impairments related to 13 types of visual impairments, and to provide specific examples. We determined the types of visual impairments, the frequency of each impairment, and what effect they exerted on daily life.

Results: Seventeen participants were included. Sixteen participants had defective visual search, 15 had hemianopic dyslexia, 10 had walking trajectory deviations, and 7 had difficulty in recalling the place where they were seeing right before. In addition, there were defective visual counting, difficulty in judging distance, and pure alexia.

Conclusion: Even in cases without severe movement disorder, aphasia, general inattention, and hemispatial neglect, cerebral infarction in the posterior half of the cerebrum causes problems in ADL due to visual impairment. It is important to interview patients from the acute stage with visual impairment in mind.

Keywords: visual impairment, acute stroke, symptom, questionnaire, defective visual search

Introduction

Approximately 30% of all stroke patients experience post-stroke visual impairment [1]. Hemianopia is the most prominent symptom in these patients, but in a survey of visual disorders after stroke, patients reported issues with visual-spatial perception, object and space recognition, contrast sensitivity, etc. [2]. These impairments are more complicated to diagnose but can be debilitating in regard to daily activities [3]. Specific interviews are critical to detecting such symptoms. The prevalence of visual problems is approximately 48% during the acute phase of stroke [4]. Often, the central aim of acute phase rehabilitation for stroke is to improve activities of daily living (ADL) related to movement disorders. Therefore, if their movement disorder is mild, patients are often discharged in the acute phase. As a result, that visual impairment that has been overlooked may have a detrimental effect on ADL. Several studies have reported effective rehabilitation, such as saccadic eye movement training in field defects, training of systematic visual search, and eye movement training for reading, for various visual impairments arising after strokes [2, 5]. We believe, therefore, that systematically examining patients for visual impairments in acute care hospital wards is vital to improving patients' quality of life. However, to the best of our knowledge, this has not yet been attempted in a research setting. Further, many ADL assessments relating to movement disorders in patients in acute care wards utilize reference criteria other than the bowels and bladder in the Barthel Index (BI). We believe, however, that in some cases, activities covered as BI criteria become difficult to perform due to visual impairment. However, it is not clear which activities are affected or how they are affected.

If patients, in addition to visual impairment, have aphasia, general inattention, or hemispatial neglect, it is possible that their vision disorder will be masked. Vision-related symptoms occur due to damage to the occipital, temporal, and parietal lobe of the cerebral cortex, but not when the damage is anterior of the central sulcus. In cases of cerebral infarctions there is comparatively good mapping between the location of the abnormality on brain images and the damaged area; thus, they are suitable for the study of responsible lesions. Therefore, this study aimed to determine the type and frequency of visual impairments and the effect on ADL in acute stroke patients with lesions in the cortical and subcortical white matter posterior to the central sulcus, and without severe movement disorder, aphasia, general inattention, or hemispatial neglect.

Materials and subjects

The participants comprised consecutive stroke patients who were admitted to the acute care hospital, Omori Red Cross Hospital, between September 2018 and May 2020. We wished to include patients with infarctions in posterior cerebral regions, and without severe movement disorder, aphasia, general inattention, and hemispatial neglect or bilateral visual field loss. The

inclusion criteria were thus as follows: head diffusion magnetic resonance imaging during hospitalization indicated new changes in lesions in the cortical and subcortical white matter posterior to the central sulcus, a score of ≥70 on the BI, an auditory comprehension score of ≥8/10 in the Western Aphasia Battery, a digit span of ≥5, a score of ≤2 on the Catherine Bergego Scale, and no bilateral visual field loss. Patients with residual dysfunction from ocular diseases, orthopedic maladies, or neurological or psychiatric illness were excluded.

This study was approved by the ethical committee of Yamagata Prefectural University of Health Science and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent after receiving a detailed description of the study.

Methods

Measurement of the visual field

The visual field was measured using a tangent screen at a visual angle of 25° from the gazing point. A hole was made in the gazing point of the screen and the test was performed from there while the participant's gaze was confirmed.

Subjective awareness of visual field loss

Before the above-mentioned visual field measurement, participants were asked whether there was anything in their visual field that they found difficult to see. They were asked again after the visual field measurement. If the patient remained unaware of their visual field loss even after the measurement, we considered that the patient had anosognosia for hemianopia [6].

Questionnaire

The questionnaire is provided in Table 1. Some of the questions related to the BI items are transfer, feeding, grooming, dressing, toilet use, bathing, mobility, and stairs (Table 1A), and the other questions related to ADL in other situations (Table 1B). The questions described problems that might occur due to some kind of visual impairment, and asked participants whether or not they had experienced these problems after their strokes. If the patient replied that they had experienced these problems, they were asked to provide further details, which were cross-referenced with the academic literature, and the vision impairment was confirmed. After each question, we asked "Have your nurses or rehabilitation staff or your families pointed this out to you?" After the questionnaire was completed, we asked participants if they had any concerns other than what they had been asked about (Table 1C).

The visual impairments we assumed that could affect ADL during hospitalization were as follows. Disability of body orientation [7], defective visual search [2, 5, 8], visuomotor ataxia [8], difficulty in judging distance [10, 11], defective contrast sensitivity [2, 5], alexia [12], hemianopic dyslexia [2, 5], prosopagnosia [13], visual object agnosia [14], object orientation

agnosia [15], and defective visual counting [16, 17]. In addition, the participants were asked about deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before, which are common post-stroke impairments.

Furthermore, we asked about the following neuropsychological symptoms that are not visual impairments but that might occur due to changes in the cortical and subcortical white matter posterior to the central sulcus that might affect ADL during hospitalization. These were personal neglect [18], ideational apraxia [19], dressing apraxia [20], heading disorientation [21], and agraphia [22].

The type and characteristics of each of these visual impairments and non-visual neuropsychological symptoms are shown in Table 2. The name of the symptom after the arrow in Table 1 expresses the probable visual impairment and other neuropsychological symptoms if the patients answer that they have problems with the questions that appear before the arrow.

From the interview results, we determined the types of visual impairments experienced by the patients, and what effects they exert on the patients' daily life.

Results

Between September 2018 and May 2020, 447 patients were admitted to our hospital with cerebral infarctions. Of them, 17 patients met the criteria for participation. Table 3 shows the demographic and clinical characteristics of each participant. The median time between stroke onset and the survey was 4 days (range 2-50 days), and the median hospital stay was 24 days (range 4-27 days). All participants were right-handed, and their midpoint BI score was 100 (range 75-100).

Regarding visual field loss, three participants had homonymous hemianopia, eight had upper quadrantanopia, two had lower quadrantanopia, and four did not have visual field loss (Table 4). Among the 13 participants with visual field loss, six did not have subjective awareness of the loss before visual field testing. Three of them became aware of the loss after the visual field testing while the other three remained unaware even after testing. That is, three participants exhibited anosognosia for hemianopia.

The following is a list of the visual impairments that affected ADL during hospitalization. Sixteen participants (94%) had defective visual search, 15 (88%) had hemianopic dyslexia, 10 (59%) had deviation of walking trajectory, 7 (41%) had difficulty in recalling the place where they were seeing right before, 3 (18%) had defective visual counting, 2 (12%) had difficulty in judging distance, and 1 (6%) had pure alexia. All of the 10 participants who had deviation of walking trajectory complained of deviations toward the opposite side of the lesion, and 7 out of the 10 participants had no subjective awareness of deviation and only described having had it pointed out by nurses and rehabilitation staff (Table 3). All patients had subjective awareness of all other symptoms. None of the participants reported difficulties related disability of body

orientation, visuomotor ataxia, defective contrast sensitivity, prosopagnosia, visual object agnosia, or object orientation agnosia.

Among the impairments, defective visual search, deviation of walking trajectory, and difficulty in judging distance were reported in response to questions regarding BI. Defective visual search was reported in response to questions relating to BI and questions relating to other visual activities. Defective visual search was reported as follows in response to questions relating to the BI. To questions pertaining to "Mobility," seven participants answered that they "bumped into things," or "people suddenly appeared and startled me." To questions related to "Grooming," five participants answered that "it takes a long time to find my tools," and to questions related to "Feeding," four participants answered that they "noticed that some of their food had been left on the plate." Deviation of walking trajectory to opposite side of the lesion and difficulty in judging distance were only reported in response to questions relating to BI. To questions regarding "Mobility" and "Stairs," difficulty in judging distance was reported, such as "I was surprised to find that I was about to sit in front of the chair," "I can't tell how far I am from objects and people when I walk," and "when I go down the stairs I can't tell the height of a step, so it's scary."

Concerning the answers to questions relating to nonvisual neuropsychological symptoms, one participant reported agraphia of kanji characters, one reported acalculia, and one reported mild amnesia (Table 5). No other non-visual neuropsychological symptoms were reported.

To the final question, in which the participant was asked about experiences that concerned them other than what was asked in the interview, one participant (6%) reported photophobia; four (24%) reported simple visual hallucinations, such as "seeing stripes"; two (12%) reported complex visual hallucinations, such as "seeing people"; two (12%) reported cerebral diplopia, in which the viewed object appears to be duplicated twice; one (6%) reported metachromatopsia, where the perceived color is different from the actual color; and two (12%) reported metamorphopsia, where the perceived shape is different from the actual one (Table 5) [5, 23, 24].

Discussion

This study aimed to determine the effect of the type and frequency of visual impairments on ADL in acute stroke patients. Our results suggest that patients who have had acute strokes with lesions in the cortical and subcortical white matter posterior to the central sulcus feel that they have problems in ADL due to various visual impairments, even if they do not have impairments that clearly hamper daily life, such as movement disorder, aphasia, general inattention, or hemispatial neglect. The symptoms frequently observed were defective visual search, hemianopic dyslexia, deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before.

According to Zihl [5], 61% of patients with homonymous hemianopia complained of ADL problems due to defective visual search. The number of patients who report ADL impairments decreases with time due to the natural recovery process after stroke and because patients consciously or unconsciously perform compensatory actions. Therefore, it is to be expected that the prevalence of ADL impairments is high in the acute phase, as was observed in our study. A subset of patients report symptoms that do not improve over the long term; these patients do not use compensatory mechanisms. Such patients have lesions on the thalamus, parietal lobe or the fibers connecting them [5].

It was previously thought that defective visual search was caused by the patient being unable to make sufficiently large eye movements to compensate for the missing part of the visual field and being unable to organize visual information on the missing side. It is now known that the severity of this impairment does not correlate with the size of the remaining visual field or the patient's subjective awareness of the visual field loss [5]. It has become clear that in some cases, similar impairments occur if lesions are present in the posterior parietal area even without visual field loss [8]. Thus, it is conceivable that this symptom can be present if homonymous visual field loss or posterior parietal lesions occur in the acute period. As shown in Tables 2 and 3, all of the patients presenting with this symptom met one of these conditions. The fact that these symptoms were observed regardless of the patient's subjective awareness of visual field loss is in line with previous findings [8].

According to Zihl [5], 77% of patients with left homonymous hemianopia and 90% of those with right homonymous hemianopia complained of hemianopic dyslexia. This is in line with our current findings. Hemianopic dyslexia was previously considered to be a reading impairment caused by characters seeming to abruptly appear and disappear from the boundary between the healthy visual field and the blind visual field. However, it has been reported that similar reading difficulties can occur in the absence of visual field loss if there are posterior parietal lesions [8]. Recently, the association between such difficulties and certain types of visuospatial attention or eye movement control has been proposed [25]. Therefore, it is conceivable that these symptoms can present if there is homonymous loss of visual field or posterior parietal lesions in the acute period. As shown in Tables 2 and 3, all of the patients presenting with this symptom met one of these conditions.

There are reports that the walking trajectory of patients with hemispatial neglect deviate to the same side as the lesion [26]; however, we could not find any studies of patients with posterior lesions without hemispatial neglect whose walking trajectory deviate to the side opposite to the lesion. However, in one study, when patients were asked to point in the direction they believed was straight ahead, patients with hemispatial neglect but not homonymous hemianopia pointed to a spot that deviated from the exact center toward the lesion side, and patients with homonymous hemianopia but not hemispatial neglect pointed to a spot that deviated from the exact center toward the side opposite to the lesion [27]. It is prudent to assume

that the latter patients, when attempting to walk straight ahead, will exhibit walking trajectory deviating to the side opposite to the lesion. However, the study did not survey a patient group with posterior lesions but without neglect or hemianopia; thus, it is unclear whether hemianopia is a requirement for the symptom of tilting toward the side opposite to the lesion. In this study, this symptom was also reported in patients without visual field loss. This suggests that the mechanism of this symptom is unrelated to the state of the visual field. This impairment differed from the other symptoms in that many patients were unaware of its existence. Danger arises when patients have comorbid deviation of walking trajectory and defective visual search, as they will approach obstacles without noticing them. Hence, those caring for the patient should be alert to the presentation of this symptom.

It is not uncommon for stroke patients to complain of difficulty in recalling the place where they were seeing right before. However, we were unable to find any studies that investigated this problem directly. However, it can be anticipated that this impairment will cause various problems with daily activities. For example, Inoue et al. [17] theorized that this symptom underlies defective visual counting.

While uncommon, some patients in our study had defective visual counting, difficulty in judging distance, or pure alexia. Defective visual counting has come to be thought of as a manifestation of visual inattention [16]. In the cases with visual inattention, severe impairment, such as the inability to count four or fewer objects, is observed. However, some patients are unable to count five or more similar items even if visual inattention is not present [16]. This type of defective visual counting occurs even if the items are lined up and not haphazard, or if they are arranged vertically. Thus, this cannot be explained by defective visual search or hemianopia. There are reports of difficulty in judging distance with bilateral lesions [9], but this symptom can also occur with unilateral legions [11]. It has been hypothesized that the lesions responsible for this symptom occur in the cuneus [10]. The cuneus was involved in all of the lesions of the patients who complained of difficulty in judging distance in this study. It is assumed that the lesions responsible for pure alexia are in the left lingual gyrus and the parahippocampal gyrus [12]. Lesions in these regions were observed in the patients who complained of pure alexia in this study.

In response to questions relating to the BI, patients reported defective visual search, deviation of walking trajectory, and difficulty in judging distance. Thus, our results indicated that even within the activities assessed by the BI, under the categories of “Mobility,” “Grooming,” “Feeding,” and “Stairs,” patients had difficulties with impairment of visual function, not with movement function. Even if there is adequate improvement in movement function, patients may not be able to succeed in the activities themselves if visual impairments are not addressed.

To manage the various symptoms described above, effective rehabilitation strategies such as training, compensation, and environmental adjustment have been reported [2, 5]. It has been reported that patients who experience visual impairment following a stroke whose impairment

goes unnoticed by others, who do not receive sufficient information, and who do not have the opportunity to receive systematic rehabilitation believe that the process of tackling their visual impairment is not supported [28]. In order to improve patient quality of life, we believe it is important to interview stroke patients in the acute stage in order to identify potential visual disorders, provide descriptions of symptoms, and consider necessary measures such as rehabilitation.

Study limitations

This study had a number of limitations. The number of participants was unfortunately small because we excluded patients with severe movement disorder, aphasia, general inattention, and hemispatial neglect. In order to obtain an adequate conclusion regarding the frequency of symptoms and extent of changes, it is necessary to recruit and follow-up participants over a long-term period in the future. In addition, this study utilized only a questionnaire. No examinations or measurement were conducted regarding each and every assumed symptom. Therefore, we did not obtain details of the symptoms or quantitative characteristics. In the future, it will be necessary to develop methods for examining and measuring each of the symptoms, analyze their characteristics, and perform a quantitative study.

Conclusion

The results of this study suggest that many patients who have had acute strokes with lesions in the cortical and subcortical white matter posterior to the central sulcus have visual impairments such as defective visual search, hemianopic dyslexia, deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before, and that these impairments caused difficulties with ADL. Therefore, we believe that is important to interview patients during the acute stage with visual disorders in mind, and if symptoms are discovered, to conduct the necessary rehabilitation.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Table 1 Questions relating to activities of daily living

What activities do you have trouble within your daily life? We would like you to tell us about activities you have trouble within your daily life. Which of the following activities are you able to perform adequately? Please tell me what problems you are having and how you are compensating for them.

A. Questions Relating to the Barthel Index

Transfer (bed to chair and back)

1. Can you lie down to sleep in bed in the correct position (with your head on the pillow and your body positioned along the bed)? →**Disability of body orientation**
2. Can you sit correctly in a chair (if the chair has a back, with your back against the back)? →**Disability of body orientation**

Feeding

1. Can you eat on your own?
2. Have others told you that you have left food on the plate after you finished eating, or have you noticed it afterwards? →**Defective visual search**
3. Can you reach for dishes correctly and smoothly? →**Visuomotor ataxia** or **difficulty in judging distance**
4. Have you ever missed your cup when pouring tea? →**Visuomotor ataxia** or **difficulty in judging distance**
5. Please tell us about any other difficulties you have with eating.

Grooming

1. Can you perform grooming activities (hand-washing, face-washing, brushing teeth, shaving, makeup, etc.) on your own? →**Ideational apraxia**
   After you thought you had finished these activities, have others told you that you had missed some places, or have you noticed it afterwards? →**Personal neglect** or **defective visual search**
2. Are you easily able to find the correct grooming items if there are many items around the washbasin? →**Defective visual search**
3. Please tell us about any other problems you have with movements around the washbasin.

Dressing

1. Can you change clothes or shoes by yourself? What do you need help with?
2. Can you quickly and correctly put on your clothes? →**Dressing apraxia**
3. Please tell us about any other difficulties you have with dressing and putting on shoes.

Toilet use

1. Can you manage all toileting activities from entering the bathroom to exiting the bathroom by yourself?
   What do you find difficult?
   Is it sitting on the toilet seat? →**Disability of body orientation**
   Is it using toilet paper? Is it using the button to flush the toilet? →**Ideational apraxia**

Bathing

1. Can you manage bathing all by yourself?
2. Can you find the soap, shampoo bottle, etc. and pick them up smoothly? →**Defective visual search**
   Can you use soap and shampoo correctly? →**Ideational apraxia**
3. Please tell us about any other problems you have with bathing.

Mobility (on level surface)

1. Can you walk in a straight line down the hallways of the ward? Do your trajectory deviate? →**Walking trajectory deviation**

Which side do your trajectory deviate?

2. When you are walking, do you sometimes bump into people or things? →**Defective visual search**
Which side are the things you bump into on? What part of your body do you bump the most?

3. Can you move around your room when it is dark in the morning, evening and after lights out? Why are you having difficulty moving around? →**Defective contrast sensitivity**

4. Can you get to the dining room or communal bath on the ward by yourself? Can you get back to your room from the ward without getting lost? →**Heading disorientation**

5. Do you sometimes have difficulty judging how far away people or things are? →**Difficulty in judging distance**

6. Have you ever tried to sit in front of or behind a chair, or grasped an object in front of or behind where it was, or bumped into a wall thinking that there was still space between you and the wall? →**Difficulty in judging distance**

Stairs

1. Can you climb up and down stairs by yourself without any problems? If not, why not? →**Difficulty in judging distance**

B. Questions not relating to the Barthel Index

1. Can you read and write characters the same way you did before you got sick? →**Agraphia, alexia**
2. Can you read sentences the same way you did before you got sick? →**Hemianopic dyslexia**
3. Do you ever look at a familiar family member or friend and not know who they are? Do you know who they are if you hear their voice? →**Prosopagnosia**
4. Do you ever look at something and not know what it is? Do you know what it is if you touch it? →**Visual object agnosia**
5. Do you ever have trouble finding the things that you need that are around your bed? →**Defective visual search**
6. Do you ever have trouble finding the things that you need that are in your hospital room? →**Defective visual search**
7. Can you find your therapist in the rehabilitation room? →**Defective visual search**
8. Can you punch the buttons on a television remote control and the keys on a calculator without difficulty?
   What do you find difficult about it? →**Visuomotor ataxia**
9. When you type on the keyboard of a PC, do you sometimes hit the wrong keys? →**Visuomotor ataxia**
10. Do you have difficulty in recalling the place where they were seeing right before?
    → **Difficulty in recalling the place where they were seeing right before**
11. Do you ever find it difficult to count objects?
    Is it harder to count objects if they are scattered around? →**Defective visual search**
    Is it harder to count objects if they are lined up? Is it when they are lined up vertically or lined up horizontally?
    →**Defective visual counting**
12. When you have trouble identifying things, is it when objects, pictures and characters are facing up, facing down, or on their sides? →**Object orientation agnosia**
13. Have other people pointed out to you that you are reading the newspaper or other reading material upside down?
    →**Object orientation agnosia**

C. Have you had other annoying experiences that we have not yet asked you about?

The name of the symptom after the arrow expresses the probable visual impairments and other neuropsychological symptoms if the patient answers that they have problems with the questions that appear before the arrow.

Table 2 The types and characteristics of impairments

Types of impairments	Characteristics
A. Visual impairments	
Disability of body orientation	Difficulty matching the axis of one's own body and a viewed object correctly [7].
Defective visual search	Difficulty moving gaze to find objects [2, 5, 8].
Visuomotor ataxia	The hand reaching for the viewed object deviates up-down, left-right, or forward-back [9].
Difficulty in judging distance	Inability to visually judge depth distance [10, 11].
Defective contrast sensitivity	Inability to distinguish low-contrast objects [2, 5].
Alexia	Becoming unable to read characters [12].
Hemianopic dyslexia	Difficulty reading sentences, skipping words, and reading the same part of the text repeatedly [2, 5].
Prosopagnosia	Seeing faces but being unable to recognize them [13].
Visual object agnosia	Seeing objects but being unable to determine what they are [14].
Object orientation agnosia	Unable to determine object orientation [15].
Defective visual counting	Difficulty counting items [16, 17].
B. Nonvisual neuropsychological symptoms	
Personal neglect	Difficulty perceiving own body on the contralateral side of the lesion [18].
Ideational apraxia	The patient cannot use tools correctly despite knowing what they are [19].
Dressing apraxia	The patient can explain how to dress and can dress others, but cannot dress themselves properly [20].
Heading disorientation	The patient gets lost in a place where the scene cannot be viewed in its entirety [21].
Agraphia	The patient can no write characters [22].

Table 3 Demographic and clinical characteristics

Patient o.	Age (years)	Sex	Symptoms on admission	BI	WAB Auditory comprehension (max: 10)	WAB Naming (max: 10)	Digit span	CBS (range: 0-30)	BIT Line bisection (max: 9)	BIT Line Cancellation (max: 36)	BIT Star cancellation (max: 54)	Lesions
1	84	f	Left scotoma	95	10	10	7	1	9	36	48	Right CUN, IPS, CAL, LOinf, FUS, and LIN
2	79	m	Right hemiplegia, vertigo	80	10	10	6	1	6	30	53	Left LOinf, FUS, LIN, and PLIC
3	53	f	Left hemianopia	100	10	10	9	0	9	36	54	Right LIN and PHIP
4	43	f	Right hemianopia, right hemiplegia	100	10	10	9	0	9	36	54	Left PHIP, FUS, and LOinf
5	68	m	Weakness in the left lower limb	80	10	10	5	2	9	35	52	Right PostC, CUN. Left SFG, CS, and IPS
6	75	m	Dysarthria, left hemiplegia	95	10	10	5	1	9	35	50	Right ITG, MTG, CR, PreC, PostC and ANG; left IC

7	66	m	Collide with objects on the right	100	8.8	6.8	6	0	9	36	53	Left HIP, PHIP,LIN, and LT
8	68	m	Vertigo	100	10	10	7	1	9	35	52	Right CCspl, LIN, and PHIP
9	77	m	Right hemianopia	100	10	10	8	1	9	36	54	Left LOsup, LIN, PHIP, and FUS
10	63	f	Transient loss of consciousness	95	10	9.2	7	2	9	36	53	Left IPS, right CR
11	70	f	Left hemianopia	100	10	10	7	0	9	36	52	Right FUS, LIN, and PHIP; left CERB
12	49	m	Right hemianopia	100	10	9.2	6	0	9	36	54	Light PHIP, LIN, and MTG.
13	56	m	Left hemianopia	100	10	10	7	0	9	36	54	Right LIN
14	88	f	Vertigo	80	10	10	5	1	9	34	50	Left STG, MTG, and ANG
15	83	m	Left hemiplegia	75	10	10	7	2	9	33	48	Right IPS, ANG, SMG, TS, and PLT
16	78	f	Left hemianopia	100	10	10	7	0	9	36	54	Light LIN and PHIP

17	90	f	Left lower limb paresthesia	85	10	10	5	0	9	34	48	Right IPS and CR

Max: maximum; BI: Barthel Index; WAB: Western Aphasia Battery; CBS: Catherine Bergego Scale; BIT: Behavioral Inattention Test; CUN: cuneus; IPS: intraparietal sulus; CAL: calcarine sulcus; LOinf: inferior occipital gyrus; LOsup: superior occipital gyrus; FUS: fusiform gyrus; LIN: lingual gyrus; PHIP: parahippocampal gyrus; PLIC: posterior limb of internal capsule; SFG: superior frontal gyrus; CS: central sulcus; ITG: inferior temporal gyrus; MTG: middle temporal gyrus; STG: superior temporal gyrus; CR: corona radiate; PreC: precentral gyrus; PostC: postcentral gyrus; IC: insular cortex; HIP: hippocampus; PLT: posterolateral thalamus; CCspl: splenium of corpus callosum; CERB: cerebellum; ANG: angular gyrus; SMG: supramarginal gyrus; TS: temporal stem

Table 4 Patterns of visual field loss and visual symptoms corresponding to questions

Patient No.	Homonymous field loss	Unawareness of hemianopia	Defective visual search	Hemianopic dyslexia	Walking trajectory deviation to the side opposite to the lesion	No awareness of deviation	Defective visual counting	Difficulty in recalling the place where they were seeing right before	Difficulty in judging distance	Pure alexia
1	Left HA	0	+	+	+	-	+	+	+	-
2	Right HA	2	+	+	+	-	+	+	-	-
3	Left HA	0	+	+	+	+	-	-	-	-
4	Right UQ	0	+	+	-		-	+	-	-
5	Left LQ	1	+	+	+	+	-	-	+	-
6	-		+	+	+	+	-	-	-	-
7	Right UQ	2	+	+	-		-	+	-	-
8	Left UQ	0	+	+	+	+	-	+	-	-
9	Right UQ	0	+	+	+	-	-	+	-	-
10	-		+	+	+	+	-	-	-	-
11	Left UQ	1	+	+	+	+	-	-	-	-
12	Right UQ	0	+	-	-		-	-	-	+
13	Left UQ	0	+	+	-		-	-	-	-
14	-		+	+	+	+	-	-	-	-
15	Left LQ	2	+	+	-		+	-	-	-
16	Left UQ	1	-	+	-		-	+	-	-
17	-		+	-	-		-	-	-	-

0: Subjective awareness prior to visual field examination; 1: Subjective awareness after visual field examination; 2: No subjective awareness even after visual field examination; +: Symptom reported; -: Symptom not reported; HA: hemianopia; UQ: upper quadrantanopia; LQ: lower quadrantanopia

Table 5 Voluntarily reported visual symptoms and non-visual symptoms corresponding to questions

Patient No.	Photophobia	Simple visual hallucination	Complex visual hallucination	Cerebral diplopia	Metachromatopsia	Metamorphopsia	Agraphia for Kanji	Acalculia	Amnesia
1	-	+	+	-	-	-	-	-	-
2	-	-	-	+	-	-	-	-	-
3	+	+	-	-	-	+	-	-	-
4	-	-	-	+	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	+	-	-	-	-
7	-	-	-	-	-	-	-	-	+
8	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	+	-	-	-
10	-	+	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	+	+	-
13	-	+	+	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-

+: Symptom reported; -: Symptom not reported