Journal of Nursing Science
2020; 6(1): 1-9
http://www.aascit.org/journal/jns
ISSN: 2381-1056 (Print); ISSN: 2381-1064 (Online)

American Association for Science and Technology

Unilateral Spatial Neglect in Stroke Patients

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Citation

Yiting Chen, Zheng Li. Unilateral Spatial Neglect in Stroke Patients. *Journal of Nursing Science*. Vol. 6, No. 1, 2020, pp. 1-9.

Received: July 30, 2020; **Accepted:** September 3, 2020; **Published:** September 24, 2020

Abstract: Unilateral Spatial Neglect (USN) is a spatially specified deficit due to an acquired cerebral lesion. Stroke patients with USN fail to detect and/or respond to stimuli located contralaterally to their hemispheric lesion. In USA, half a million people died of stroke and fifteen million people were suffered with stroke. Estimates of the incidence of USN after stroke vary from 20% to 82%, and the impacts of USN can be far-reaching for patient's daily life, such as aggravating the severity of stroke and increasing patients' finance burden. The types of USN are miscellaneous, and different assessments and interventions make widely divergent prognoses. The pathogenesis of USN has not been clarified completely, and the assessments and managements lack a unified and effective method. It is necessary to synthesize related research results in order to have a holistic grasp of USN after stroke comprehensively. The purposes of this review were to summarize the definition and classifications of USN in stroke patients, to analyze contributing factors and outcomes associated with USN. The assessments and managements of post-stroke USN were emphatically reviewed, so as to provide professionals with a full understanding of the symptom, effective assessment tools and management methods for better prevention and treatment of USN.

Keywords: Unilateral Spatial Neglect, Stroke, Symptom, Review

1. Introduction

According to statistics data, the global prevalence of stroke was 1363.5/100000 in 2017, while the prevalence was 2393.7/100000 in China [1]. In USA, half a million people died of stroke and 15 million people were suffered with stroke in 2017 [1]. Many stroke survivors have different levels of disability after stroke, the complications and symptoms of stroke decrease the quality of life drastically, and bring heavy burden on individuals, families and whole society [2]. Stroke is often accompanied by neurocognitive disorders [3]. Unilateral spatial neglect (USN) is a perplexing neuropsychological syndrome, affecting different domains of spatial cognition and impacting also the functional domain [4]. Specifically, Stroke patients with USN fail to detect and/or respond to stimuli located contralaterally to their hemispheric lesion [5]. USN is present in at least 30% of all stroke survivors [6], and occurs in approximately 50% of right-hemisphere stroke patients [7]. Unfortunately, although spontaneous recovery may occur, it will not inevitably eliminate all signs of neglect, many of the patients do not recover completely [8]. In addition, patients with USN always have a poor long-term prognosis on functional outcome [9]. The symptoms of USN were not paid enough attention in the early stage due to the variety of manifestations, and most of them were accompanied by the decline of neurological function, which seriously affected the patients. The pathogenesis has not been clarified, and the assessments and managements lack a unified and effective method. The lack of holistic grasp of USN after stroke, makes it necessary for us to synthesize related research results in order to understand USN comprehensively.

Therefore, in the present review we will 1) describe the definition and classifications of USN in stroke patients; 2) analyze contributing factors and outcomes associated with USN; 3) summarize the assessments and managements of USN after stroke.

2. Definition of USN

The nomenclature of USN is interchangeable among articles including Spatial neglect (SN), Unilateral neglect (UN), hemispatial neglect, hemineglect, hemi-inattention, and neglect syndrome. Unilateral spatial neglect is a consistent and exaggerated spatial asymmetry in processing information in bodily and/or extrabodily space due to an acquired cerebral

lesion, encompassing both omission errors and commission errors [10]. It is characterized by an inability to detect and respond to visual or tactile stimulus from people or objects that are presented contralateral to the lesion side of the brain when these symptoms cannot be attributed to either motor or sensory deficits [4, 9, 11-14].

3. Classifications of USN

The neglect symptoms after stroke are complex and diverse, so we introduce them according to different classification standards.

3.1. Classified by Neglect Spatial Domain

According to neglect spatial domain, USN could be classified into four broad categories: Personal space neglect, Near space neglect, Far space neglect and Representational space neglect. This is one of the most common classifications. Personal space neglect is the hemi-inattention toward the contralesional bodily space that follows a cerebral lesion, usually to the right hemisphere [15], making left foot fall down from the pedal in the wheelchair, neglecting the left side face when washing face or makeup and so on. The patients with near space neglect can often neglect to deal with the objects within their reach (in near space) [16]. They cannot find the glasses placed on the affected side, bump into an obstacle on the affected side when driving a wheelchair, or neglect the food on the affected side when eating. Diametrically, far space neglect patients neglect to deal with the objects out of their reach (in far space) [16]. They neglect people or ornament in the room, or are unable to identify the environmental orientation of the affected side. Representational space neglect means that patients cannot describe their mental images from their long-term memory excluding the obstacles of memory and external stimulus response [16, 17]. Right-sided brain damage stroke patients with representational space neglect can only describe the familiar right-side scene by memory but not the left side, or neglect left side of self-portrait.

3.2. Classified by Neglect Content

USN can be classified into sensory neglect and motor neglect according to neglect content. Sensory neglect will weaken stroke patient's ability of hearing, touching and visual sense of the affected side, also called inattention [16]. Meanwhile, motor neglect patients only raise the unaffected-side arm when asked to raise their both arms, or the unaffected-side hand can only move in the unaffected-side space [18].

3.3. Classified by Reference Frame

There are space-based neglect and object-based neglect when classified by reference frame. Space-based neglect is also called egocentric (viewer-centered) neglect, it means patients define the left and right sides of space according to their midlines, so they may neglect the things on their left or right side [19, 20]. Object-based neglect is also called allocentric neglect, described as a failure to perceive the contralesional side of an individual stimulus regardless of its position or location in space [21]. Patients define the left and right sides of space according to the objects' midlines.

3.4. Other Special Performances

3.4.1. Neglect Dyslexia

Stroke survivors with USN typically fail to detect stimuli on the left side of space and show specific reading impairments because of right hemispheric brain damage [22, 23]. Specifically, reading errors related to USN may occur in the contralesional side of the stimulus when patients read single words, phrases, or prose [24]. Neglect dyslexia is classified into various kinds, such as viewer-centered, stimulus-centered, or word-centered neglect dyslexia [25].

3.4.2. Crossed Leg Sign

USN is frequently demonstrated in the clinic as misinterpretation of the midline, which may present crossed leg sign. This sign is characterized by an overlap of the right leg over the left as the patient attempts to orient to the midline because there is a loss of spatial orientation of the left space [13]. If the left leg is not perceived or felt to be one's own limb, then abnormal rubbing movements may appear, which may be of predictive value in the development of USN [26].

4. Contributing Factors and Outcomes

4.1. Contributing Factors

The pathogenesis of post-stroke USN is very complex and has many hypotheses, which have not been fully elucidated at present. The contributing factors found so far are age, gender, stroke lesion region, hemoglobin level and so on.

Neglect occurred at higher frequency and at increasing severity in older patients among patients with acute right hemispheric stroke [27]. Sex differences were not found between anterior and posterior groups after left- or right-hemisphere strokes. However, when neglect was based on different scores between ipsilateral versus contralesional response times on a Visual Search Task, the incidence was higher in females with right-hemisphere lesions [28]. In Hammerbeck's latest study, USN after stroke was observed in a slightly older population (78 years), and more common in females than in males (33% vs. 27%) [29]. Age and gender effects might influence the onset of the symptom.

Studies in patients with USN have shown damage in the right superior and middle temporal gyri, the basal ganglia and the white matter tracts of the inferior occipitofrontal and uncinate fasciculus [8, 30]. Ringman et al. found that USN occurring in 43% of stroke patients with RBL and 20% of stroke patients with LBL ($P<0.001$), and in RBL patients, neglect was most frequently associated with lesions involving the temporal, parietal, frontal, occipital lobes, basal ganglia, and thalamus. What's more, USN was more common and persistent with cortical than with subcortical lesions [31].

Some studies found that USN can also be caused by injury or dysfunction of various structures of the attention network [32]. USN has become evident as a widespread attention network disorder [33], the dorsal attention network may be physiologically impaired across the wide variety of right hemisphere ventral fronto-parietal lesions that can produce neglect, and the interaction of ventral attention network and dorsal attention network is critical for recovery [34].

The hemoglobin level has also been found to be associated with USN. Low hemoglobin levels may indicate a worse performance in USN cancellation and bissection tests in acute phase of stroke. However, more high quality researches are needed to verify [35]. A latest study also found that USN was observed more commonly was for individuals with congestive heart failure in comparison to those without CHF (34% vs. 30%) and atrial fibrillation in comparison to individuals without AF (38% vs. 28%). And USN was detected more often in haemorrhagic stroke (36% vs. 30%) [29]. Thus, the type of stroke and other underlying disease may also have impacts on USN.

4.2. Adverse Outcomes

As a common and complicated sequela of stroke, USN can be far-reaching for patient's daily life. Firstly, USN can aggravate the severity of stroke and make recovery process slower. Stein et al. found there was a significant disadvantage in USN patients overall functional ability and sensory-motor components on the Barthel Index, Functional Independence Measure (FIM) and Rivermead Mobility Index (RMI) [36]. Note that some studies found USN and anosognosia often co-occur post-stroke [37, 38]. But Dauriac et al. reported two patients presenting with a subacute right hemisphere stroke, one of them suffered from a severe left hemiplegia associated with USN but he appeared fully aware of his motor impairment, while the other patient had a severe left hemiplegia without USN presented a severe anosognosia. Hence, the assumption that USN and anosognosia may rely on independent mechanisms[39]. There is a need for more high-quality related research. Secondly, due to the limitation of visual condition and perception, USN patient's safety cannot be guaranteed. Falls and collisions can happen to patients more likely. Aravind et al. demonstrated that patients with USN are at greater risk of colliding with moving obstacles approaching contralesionally and from straight ahead, as opposed to obstacles approaching ipsilesionally in 2014 study. Post-stroke individuals with USN had difficulty negotiating moving obstacles while walking [40]. Furthermore, they found dual-task walking dramatically compromises both locomotor and cognitive performances of patients. Under dual-task conditions, USN stroke patients experienced further delays in initiating an avoidance strategy, reduced minimum distances with respect to the obstacle and more frequent collisions [41]. It suggests that USN increases adverse incidents of stroke patients, hinders patients from returning to normal social life to some extents. Thirdly, USN can lengthen the length of stays, increase the finance burden and reduce the life quality of whole family [42, 43]. Sobrinho et al. observed a negative correlation between USN and self-care ($r=-0.82$, $p=0.013$), usual activities ($r=-0.87$, $p=0.005$), discomfort ($r=-0.88$, $p=0.004$), anxiety or depression ($r=-0.97$, $p<0.001$), EUROQOL total score ($r=-0.97$, $p<0.001$) [44]. USN is an important predictor of reduced life satisfaction in the first year after stroke [45].

5. Assessments

Timely detection of USN and early intervention not only help to reduce the symptoms, but also benefit the rehabilitation effects of stroke patients. The assessment tools of USN are diverse, commonly used or promising tools are introduced as following.

5.1. Traditional Paper and Pencil Tests

Traditional paper and pencil test is simple and time-consuming, which improves patients' cooperation and compliance. There are many forms, such as line bisection, cancellation test, copying test, reading and writing, etc. The line bisection is a test asking patients to mark the midpoint of horizontally oriented lines drawn on the paper [46]. Similarly, Chiba et al. developed a method called midpoint-fixation task that does not require the participation of hand movement and can effectively evaluate the neglect caused by the defect of attention and perception [47]. A length effect that longer lines were nearly twice as sensitive than shorter ones. For instance, the sensitivity of line segments of 5 cm was 19.0%, and 20 cm was 37.7% [48]. Cancellation tests have many forms such as shape cancellation, letter cancellation, star cancellation, line cancellation, etc. The random shape cancellation test, star cancellation and two line bisection tasks appeared to be the most sensitive tests of USN [49]. Clock-drawing test, self-portrait test and daisy copying all belong to copying tests. The sensitivity of the picture copying test was 42.7% [48]. Copying test is much more vivid, but has higher demands on patients. The sensitivity of reading and writing test was 46.8% and 34.3% respectively [48]. Paper and pencil tests are used to assess the the two-dimensional near space, but not used in the three-dimensional space and the far space neglect test.

5.2. Standardized Set of Functional Behavior Tests

Standardized set of functional behavior tests consists of a series of functional activities related to USN, which has a clear scoring standard, can quantitatively test the severity of USN after stroke. The common functional rating scale includes Catherine Bergego Scale, Behavioural Inattention Test, Árnadóttir OT-ADL Neurobehavioral Evaluation, etc.

5.2.1. Catherine Bergego Scale

Catherine Bergego Scale (CBS) aims to assess clinical manifestations and severity of USN by observing a series of daily activities of patients. The scale comprises 10 items relating to elementary activities, each scored from 0 (normal) to 3 (severe unilateral neglect). A global score is then

calculated, ranging from 0 to 30. It has distinguish three levels of severity for CBS scores: from 1–10, mild neglect, 11–20 moderate neglect and 21–30 severe neglect. The whole process takes about 30 minutes [50, 51]. A study shows that CBS has good reliability, validity and sensitivity, which is high relevant to traditional ignore test [48]. CBS evaluates USN according to Activities of Daily Living (ADL), and ADL is a multidimensional function, so Goedert et al. suggested to further divide the 10 items of CBS into two parts: perceptual-attentional (CBS-PA) and embodied, motor-exploratory bias (CBS-ME) [52]. CBS is widely recommended as a functional measure of USN. However, it cannot distinguish whether sensory neglect or motor neglect that leads to dysfunction.

5.2.2. Behavioural Inattention Test

Behavioural Inattention Test (BIT) has two parts: traditional paper-and-pencil test (BIT-C) and behavior test (BIT-B). It comprises 6 conventional pencil-and-paper subtests and 9 behavioural subtests reflecting various aspects of daily life [53]. The more serious the USN is, the lower the score would be. BIT-C and BIT-B can be used alone. The full set of tests takes 30-40 minutes. A simplified version with good reliability and validity was developed, reducing the testing time to 10-15 minutes [54]. However, the BIT assessment requires some skills of patients such as writing, reading, visual memory and recognition, which limits early clinical application, but it's an effective tool for patients about to be discharged from the acute phase.

5.2.3. Semi-structured Scale

Semi-structured scale screened for USN by assessing the patient's performance in functional activities, such as combing hair or makeup. Zoccolotti et al. proposed an evaluation based on semi-structured situations and simulations of daily living tasks using real objects [55]. It includes personal hemineglect and extra-personal hemineglect subscales. Personal hemineglect assessment tasks include combing one's hair, using a razor (or powder compact) and wearing glasses, while extra-personal hemineglect assessment tasks includes making tea, playing cards, describing pictures, and describing the room. Each item is scored from 0 (normal) to 3 (severe). Furthermore, Beschin and Robertson refined the scoring of the personal scale by counting the number of strokes of the comb (or a razor) on each side for 30 seconds (comb and razor test) [56]. Although the Semi-structured scale has good inter-tester reliability, the evidence of repeated test reliability is not sufficient.

5.3. Single Function Behavior Tests

Although standardized set of functional behavior tests has comprehensive evaluation, its items are too complicated to complete by stroke patients. Therefore, single function behavior tests come up. They are all based on the daily life and have good clinical practicality. Common methods are Comb and Razor Test, Vest Test, Fluff Test, Wheelchair Collision Test and Baking Tray Task, etc. [57].

5.4. Computerized Methods

With the development of advanced technology, assessments based on computer offer a promising alternative approach for USN assessment and are able to identify subtle deficits that traditional tests might miss [58]. Pedroli et al. reviewed 13 studies to provide an overview of the most recent VR applications for the assessment of USN. They found the VR tests were various, such as 3D immersive VR program for street-crossing [59], VR program for counting the number of bus stops the patients see in a virtual city [60], Virtual Reality Lateralized Attention Test (VRLAT) [61], VR Diagnostic Test Battery (VR-DiSTRO) [62], navigation tasks in a virtual room containing obstacle detection task, joystick-driven obstacle avoidance task and locomotor obstacle avoidance task [40, 63]. They can detect and measure USN easily and safely. VR assessment tools pay more attention to ergonomics and meet the needs of patients better. Nevertheless, there are challenges that may limit the use of VR assessment tools, such as the high costs and hard popularization.

6. Managements

6.1. Pharmacological Treatment

Van der et al. evaluated and reviewed 11 articles, 3 pharmacological approaches including dopaminergic therapy, cholinergic therapy and (nor) adrenergic therapy. This analysis found that cholinergic treatment seemed to be the most effective in improving USN symptoms, dopaminergic and (nor) adrenergic stimulations decreased USN symptoms in some cases [64]. However, quality assessment showed that none of the reviewed studies were of high quality in this systematic review (3 moderate quality, 8 low quality), few studies completed full requirements of a randomized controlled trial. Nevertheless, Luvizutto et al. reviewed two studies with a total of 30 randomly assigned participants and found the effectiveness and safety of pharmacological interventions for USN after stroke were uncertain [65]. More high quality randomized controlled clinical trials with large samples and long-term follow-up are expected to report about pharmacological approaches for USN after stroke.

6.2. Non-pharmacological Treatment

6.2.1. Top-down Approaches

Top-down approaches, also called extrinsic approaches, employ external cues and guidance to engage the conscious and purposeful involvement of the patient [66]. Visual scanning training (VST) is the earliest and most widely used top-down approach. Patients are encouraged to pay attention to portions of space contralateral to the brain lesion through various training tasks, such as visual search, picture exploring, reading and writing during VST [67, 68]. Code proposed a model involved two different processes restoration and compensation [69]. According to this framework, VST involves a behavioural compensatory mechanism. Through compensatory strategies and visual reinforcements, the exploratory behaviour of

contralesional contents of space is strengthened. Priftis et al. recruited thirty-three patients with left neglect and found VST improved USN (P<0.05) in two weeks assessed by tests for personal LN (comb and razor test, fluff test), tests for peripersonal LN (picture scanning, menu reading, coin sorting, semi-structured ecological scale), test for extrapersonal LN and CBS [70]. Collectively, VST was recommended as a treat method, and a beneficial effect was observed when the training lasted over one month [68]. Mental imagery training is another method based on top-down cognitive restoration mechanism. Smania et al. firstly confirm the possible effectiveness of mental imagery training for USN rehabilitation published in a case report in 1997 [71]. Top-down approach improves USN by acting on disrupted awareness; nevertheless, it is difficult to be applied in patients with severe neglect.

6.2.2. Bottom-up Approaches

Bottom-up approaches, also called intrinsic approaches, attempt to affect the attentional system at a preconscious level by manipulating endogenous components of the neural axis, mostly sensory input [66], such as optokinetic stimulation [72], limb activation [73], neck muscle vibration [74], trunk rotation [74], eye patching [75], prismatic adaptation [76], etc. Bottom-up approach is possible to override central awareness deficit and reach higher cognitive levels of spatial and action representation. Prismatic adaptation (PA) is a popular recent example of bottom-up approaches, takes advantage of the short-term adaptation that takes place when subjects are exposed to prism lenses that produce a shift of the visual field [66, 76]. Rossetti et al. found that USN had a significant reduction assessed by various standard tests such as line bisection, cancellation, copying and reading following a brief period (3–5min) of PA [76]. It more likely to be seen by wearing base-left wedge prisms in spectacles visual space is perturbed to the right [77]. More and more studies showed PA had improvements on USN [77, 78]. A systematic review including 30 studies (8 randomized controlled trials, 4 crossover design studies and 18 pre–post design studies) indicated that PA had a beneficial effect for USN patients in accuracy and reaction time of feature search tasks [78]. Some evidence suggested that PA could improve daily functioning measured by reading, writing tasks and ADL tests [9]. Furthermore, Shiraishi et al. performed an 8-week PA intervention, found eye movements were significantly improved on the neglected side ($p<0.01$), and the effects were sustained for up to 6 weeks after the removal of the prism, suggesting that PA had long-term effects [79]. Due to obvious effects and simple but safe operation, PA is increasingly used.

6.2.3. Repetitive Trans-cranial Magnetic Stimulation

Repetitive trans-cranial magnetic stimulation (rTMS) is an approach based on the model that competitive relationship between each cerebral hemisphere regarding spatial attention. The inter-hemispheric asymmetry regarding spatial orientation is accentuated resulting in a dramatic increase of the rightward attentional bias and generating left neglect after right brain damage [68]. Kashiwagi et al reviewed twelve RCTs and 4 non-RCTs with a total of 367 participants, and found rTMS was more efficacious for USN after stroke [80]. Miniussi et al. reviewed some studies found low-frequency (<1Hz) rTMS might lead to cortical inhibition, while high-frequency (>5Hz) rTMS might lead to cortical stimulation [81]. So it could improve USN by reducing the activity of the left hemisphere or by increasing the activity of the right hemisphere [82]. Kim et al. recruited 30 patients and found there was a significant improvement (P<0.05) for USN patients in performance of Motor-Free Visual Perception Test 3, line bisection test, star cancellation test, Albert's test, CBS, Mini-Mental State Examination and the Modified Barthel Index through low-frequency rTMS session (900 stimuli applied over contralesional posterior parietal cortex at an intensity of 95% motor thresholds and a frequency of 0.9 Hz), for 20 minutes per day, 5 days a week for 2 weeks (10 times total) [83]. However, the risk of rTMS use should be evaluated, especially in stroke patients who are seizure prone [81].

6.2.4. Virtual Reality Technology

Recently, virtual reality (VR) technologies are proposed and have increasing using [58]. VR trainings are always based on traditional methods and proved effective in USN after stroke [84-86]. Katz et al. gave 11 right hemisphere stroke patients 12 computer desktop-based Virtual Reality street crossing training sessions, 9 hours total, four weeks. The result showed VR group achieving on the USN measures results equaled with control group treated with conventional visual scanning tasks and did better on some measures of the real street crossing (P<0.05) [85]. Specially-designed VR games can also increase fun in rehabilitation. VR is one of the most recent and innovative approach for USN patients; nevertheless, its potential has been only minimally explored up to now [67].

6.3. Nursing Care

The North American Nursing Diagnosis Association (NANDA) recognized USN as a nursing diagnosis in 1986 [87]. Nurses are likely to be one of the most important elements of a stroke rehabilitation team in USN care [88]. In the conventional approach of nursing care, 'care by calling attention' is the major strategy for neglect [89]. Current nursing practices are routine [16], include redirecting patient's attention to the affected side, preventing adverse accidents, integrating care of the medical team and caregivers and so on [16]. Patients are encouraged to increase the presence of the affected side. For instance, nurses could place personal belongings on the lesion side of patients, contact patients from the affected side, encourage patients to touch affected side with healthy hand and assist them to move the affected limb. Bedrail is used in the affected side of patients to prevent falls and caregivers should assist patients when they are walking or moving. Most important of all, nurses should find out whether the patient present USN as early as possible, so as to report to doctors to give appropriate treatments [16]. To achieve better prognosis and life quality, more comprehensive and systematic nursing care should be developed for stroke

patients with USN.

7. Discussion

USN is a complex complication after stroke, patients are unable to produce a correct response to the stimulation of the damaged contralateral space of the brain.

It is highly prevalent in stroke patients which should be taken into serious consideration. USN can lead to serious negative consequences and reduce patients' quality of life. Therefore, timely and accurate evaluation is very important.

Compared with traditional paper and pencil tests, standardized set of functional behavior tests has more comprehensive evaluation, CBS and BIT are widely recommended as a functional evaluation method of USN with good reliability and validity. However, their items are too complicated to complete by patients and they are always time consuming. Single function behavior tests based on the daily life come up and have been confirmed to have good clinical practicality. The functional evaluation method effectively makes up for the deficiency of traditional paper-and-pencil test, and can provide more comprehensive, quantitative and objective evaluation. It's worth noting that assessment tools need to be selected according to the specific situation of the place and the patient.

When USN is confirmed for evaluation, appropriate interventions should be given. Pharmacological treatment is reported, and demonstrated that cholinergic, dopaminergic and (nor) adrenergic stimulations seem to decrease USN symptoms. But the evidence is not enough and pharmacological treatment is often accompanied by many side effects. There are many forms of non-pharmacological treatment, and virtual reality is used more and more widely in USN assessment and treatment. Compared to conventional treatments, VR programs such as specially-designed games requiring patients to reach some targets can also increase much fun in recovery progress. In the future treatment, more VR projects with high applicability are expected to be developed for USN rehabilitation. Nursing interventions for stroke patients with USN are routines and lack of personalization, so comprehensive and systematic approaches that account for all the facets of holistic patient care should be developed. For example, detail care program based on different period, different severity of USN and different patients are encouraged to make.

This review summarizes the definition, symptom experience, contributing factors, negative outcomes, assessments and managements of USN stroke patients so as to provide reference information for clinical rehabilitation practice. However, we found that the whole quality of studies about post-stroke USN, especially the intervention studies, is not pretty high. Management of USN is mostly general, not personalized for stroke patients. Disappointingly, rare study reported how nurses to care stroke patients with USN systematically, holistic care interventions are urgently needed. Last but not least, not only physical health, but also mental health of USN stroke patients should be taken seriously. Through literature review, we have not found psychological intervention and counseling for USN stroke patients. Therefore, mental health of USN stroke patients should be paid more attention.

Our review retrospect s the progression of USN, we hope it would help health providers to understand and manage the symptom better.

Conflict of Interest

The authors have no conflict of interest to disclose.

References

[1] GBD 2017 result [EB/OL]. [2019-04-25]. http://ghdx.healthdata.org/gbd-results-tool?params=gbd-api-2017-permalink/d0751ee757596d5620861cea64fa215d.

[2] Li Z., Jiang Y., Li H., et al. China's response to the rising stroke burden [J]. BMJ, 2019, 364: l879.

[3] Klinke M. E., Hjaltason H., Hafsteinsdóttir T. B., et al. Spatial neglect in stroke patients after discharge from rehabilitation to own home: a mixed method study. [J]. Disability & Rehabilitation, 2016, 38 (25): 2429-2444.

[4] Verdon V., Schwartz S., Lovblad K. O., et al. Neuroanatomy of hemispatial neglect and its functional components: a study using voxel-based lesion-symptom mapping [J]. Brain, 2010, 133 (Pt 3): 880-894.

[5] Ceyte H., Beis J., Simon M., et al. Lasting improvements in left spatial neglect following a protocol combining neck-muscle vibration and voluntary arm movements: a case-study. [J]. Disability & Rehabilitation, 2019, 41 (12): 1475-1483.

[6] Barrett A. M., Buxbaum L. J., Coslett H. B., et al. Cognitive rehabilitation interventions for neglect and related disorders: moving from bench to bedside in stroke patients [J]. J. Cogn Neurosci, 2006, 18 (7): 1223-1236.

[7] Buxbaum L. J., Ferraro M. K., Veramonti T., et al. Hemispatial neglect: Subtypes, neuroanatomy, and disability [J]. Neurology, 2004, 62 (5): 749-756.

[8] Wahlin A., Fordell H., Ekman U., et al. Rehabilitation in chronic spatial neglect strengthens resting-state connectivity [J]. Acta Neurologica Scandinavica, 2019, 139 (3): 254-259.

[9] Champod A. S., Frank R. C., Taylor K, et al. The effects of prism adaptation on daily life activities in patients with visuospatial neglect: a systematic review [J]. Neuropsychol Rehabil, 2018, 28 (4): 491-514.

[10] Cubelli R. Definition: Spatial neglect [J]. Cortex, 2017, 92: 320-321.

[11] Swan L. Unilateral spatial neglect [J]. Phys Ther, 2001, 81 (9): 1572-1580.

[12] Kerkhoff G. Spatial hemineglect in humans [J]. Prog Neurobiol, 2001, 63 (1): 1-27.

[13] Luvizutto G. J., Neto E. M., Resende L. A. L., et al. Crossed leg sign is associated with severity of unilateral spatial neglect after stroke [J]. Frontiers in Neurology, 2018, 9 (APR): 256.

[14] Adair J. C., Barrett A. M. Spatial neglect: clinical and neuroscience review: a wealth of information on the poverty of spatial attention [J]. Ann N Y Acad Sci, 2008, 1142: 21-43.

[15] Committeri G., Piervincenzi C., Pizzamiglio L. Personal neglect: A comprehensive theoretical and anatomo-clinical review [J]. Neuropsychology, 2018, 32 (3): 269-279.

[16] Dai C., Lin L. Nursing Care of Unilateral Neglect Patients. [J]. Journal of Nursing, 2015, 62 (1): 92-97.

[17] Bisiach E., Luzzatti C. Unilateral neglect of representational space [J]. Cortex, 1978, 14 (1): 129-133.

[18] Laplane D., Degos J. D. Motor neglect [J]. J. Neurol Neurosurg Psychiatry, 1983, 46 (2): 152-158.

[19] Karnath H. O., Rorden C. The anatomy of spatial neglect [J]. Neuropsychologia, 2012, 50 (6): 1010-1017.

[20] Arguin M, Bub D. N. Evidence for an independent stimulus-centered spatial reference frame from a case of visual hemineglect [J]. Cortex, 1993, 29 (2): 349-357.

[21] Driver J., Baylis G. C., Goodrich S. J., et al. Axis-based neglect of visual shapes [J]. Neuropsychologia, 1994, 32 (11): 1353-1365.

[22] Turgut N., Möller L., Dengler K., et al. Adaptive Cueing Treatment of Neglect in Stroke Patients Leads to Improvements in Activities of Daily Living: A Randomized Controlled, Crossover Trial. [J]. Neurorehabilitation & Neural Repair, 2018, 32 (11): 988-998.

[23] Reinhart S., Schindler I., Kerkhoff G. Optokinetic stimulation affects word omissions but not stimulus-centered reading errors in paragraph reading in neglect dyslexia [J]. Neuropsychologia, 2011, 49 (9): 2728-2735.

[24] Galletta E. E., Campanelli L., Maul K. K., et al. Assessment of Neglect Dyslexia With Functional Reading Materials. [J]. Topics in Stroke Rehabilitation, 2014, 21 (1): 75-86.

[25] Caramazza A., Hillis A. E. Spatial representation of words in the brain implied by studies of a unilateral neglect patient [J]. Nature, 1990, 346 (6281): 267-269.

[26] Bazan R., Fernandes T., Braga G., et al. A new clinical sign probably associated to left hemiplegia with left hemineglect syndrome: the crossed legs [J]. Arq Neuropsiquiatr, 2014, 72 (6): 418-421.

[27] Gottesman R. F., Kleinman J. T., Davis C., et al. Unilateral neglect is more severe and common in older patients with right hemispheric stroke [J]. Neurology, 2008, 71 (18): 1439-1444.

[28] McGlone J., Losier B. J., Black S. E. Are there sex differences in hemispatial visual neglect after unilateral stroke? [J]. Neuropsychiatry Neuropsychol Behav Neurol, 1997, 10 (2): 125-134.

[29] Hammerbeck U., Gittins M., Vail A., et al. Spatial Neglect in Stroke: Identification, Disease Process and Association with Outcome During Inpatient Rehabilitation [J]. Brain Sci, 2019, 9 (12).

[30] Karnath H. O., Rennig J., Johannsen L., et al. The anatomy underlying acute versus chronic spatial neglect: a longitudinal study [J]. Brain, 2011, 134 (Pt 3): 903-912.

[31] Ringman J. M., Saver J. L., Woolson R. F., et al. Frequency, risk factors, anatomy, and course of unilateral neglect in an acute stroke cohort [J]. Neurology, 2004, 63 (3): 468-474.

[32] Puig-Pijoan A., Giralt-Steinhauer E., Zabalza D. T. A., et al. Underdiagnosis of Unilateral Spatial Neglect in stroke unit [J]. Acta Neurologica Scandinavica, 2018, 138 (5): 441-446.

[33] Yusaku T., Maho I., Madoka O., et al. Intentional gaze shift to neglected space: a compensatory strategy during recovery after unilateral spatial neglect. [J]. Brain: A Journal of Neurology, 2016, 139 (11): 2970-2982.

[34] Corbetta M., Shulman G. L. Spatial neglect and attention networks [J]. Annu Rev Neurosci, 2011, 34: 569-599.

[35] Luvizutto G. J., Monteiro T. A., Braga G. P., et al. Low haemoglobin levels increase unilateral spatial neglect in acute phase of stroke [J]. Arquivos de Neuro-Psiquiatria, 2014, 72 (10): 757-761.

[36] Stein M. S., Kilbride C., Reynolds F. A. What are the functional outcomes of right hemisphere stroke patients with or without hemi-inattention complications? A critical narrative review and suggestions for further research [J]. Disabil Rehabil, 2016, 38 (4): 315-328.

[37] Appelros P., Karlsson G. M., Hennerdal S. Anosognosia versus unilateral neglect. Coexistence and their relations to age, stroke severity, lesion site and cognition [J]. Eur J Neurol, 2007, 14 (1): 54-59.

[38] Grattan E. S., Skidmore E. R., Woodbury M. L. Examining Anosognosia of Neglect [J]. OTJR (Thorofare N J), 2018, 38 (2): 113-120.

[39] Dauriac-Le M. V., Mailhan L., Louis-Dreyfus A., et al. Double dissociation between unilateral neglect and anosognosia [J]. Rev Neurol (Paris), 2002, 158 (4): 427-430.

[40] Aravind G., Lamontagne A. Perceptual and locomotor factors affect obstacle avoidance in persons with visuospatial neglect [J]. J Neuroeng Rehabil, 2014, 11: 38.

[41] Aravind G., Lamontagne A. Dual tasking negatively impacts obstacle avoidance abilities in post-stroke individuals with visuospatial neglect: Task complexity matters! [J]. Restorative Neurology and Neuroscience, 2017, 35 (4): 423-436.

[42] Bosma M. S., Nijboer T., Caljouw M, et al. Impact of visuospatial neglect post-stroke on daily activities, participation and informal caregiver burden: A systematic review [J]. Ann Phys Rehabil Med, 2019.

[43] Gillen R., Tennen H., McKee T. Unilateral spatial neglect: relation to rehabilitation outcomes in patients with right hemisphere stroke. [J]. Archives of Physical Medicine & Rehabilitation, 2005, 86 (4): 763-767.

[44] Sobrinho K., Santini A., Marques C., et al. Impact of unilateral spatial neglect on chronic patient's post-stroke quality of life [J]. Somatosens Mot Res, 2018, 35 (3-4): 199-203.

[45] Verhoeven C. L., Post M. W., Schiemanck S. K., et al. Is cognitive functioning 1 year poststroke related to quality of life domain? [J]. J Stroke Cerebrovasc Dis, 2011, 20 (5): 450-458.

[46] Sperber C., Karnath H. O.. Diagnostic validity of line bisection in the acute phase of stroke [J]. Neuropsychologia, 2016, 82: 200-204.

[47] Chiba Y., Nishihara K., Yamaguchi A., et al. Midpoint fixation task: quantitative assessment of visual neglect [J]. J Clin Neurosci, 2008, 15 (6): 647-649.

[48] Azouvi P., Samuel C., Louis-Dreyfus A., et al. Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke [J]. J Neurol Neurosurg Psychiatry, 2002, 73 (2): 160-166.

[49] Lindell A. B., Jalas M. J., Tenovuo O., et al. Clinical assessment of hemispatial neglect: evaluation of different measures and dimensions [J]. Clin Neuropsychol, 2007, 21 (3): 479-497.

[50] Chen P., Hreha K., Fortis P., et al. Functional assessment of spatial neglect: a review of the Catherine Bergego scale and an introduction of the Kessler foundation neglect assessment process [J]. Top Stroke Rehabil, 2012, 19 (5): 423-435.

[51] Marques C., de Souza J. T., Goncalves M. G., et al. Validation of the Catherine Bergego Scale in patients with unilateral spatial neglect after stroke [J]. Dement Neuropsychol, 2019, 13 (1): 82-88.

[52] Goedert K. M., Chen P., Botticello A., et al. Psychometric evaluation of neglect assessment reveals motor-exploratory predictor of functional disability in acute-stage spatial neglect [J]. Arch Phys Med Rehabil, 2012, 93 (1): 137-142.

[53] Kutlay S., Genc A., Gok H., et al. Kinaesthetic ability training improves unilateral neglect and functional outcome in patients with stroke: A randomized control trial [J]. J Rehabil Med, 2018, 50 (2): 159-164.

[54] Stone S. P., Wilson B., Wroot A., et al. The assessment of visuo-spatial neglect after acute stroke [J]. J Neurol Neurosurg Psychiatry, 1991, 54 (4): 345-350.

[55] Zoccolotti P., Judica A. Functional evaluation of hemineglect by means of a semistructured scale: Personal extrapersonal differentiation [J]. Neuropsychological Rehabilitation, 1991, 1 (1): 33-44.

[56] Beschin N., Robertson I. H. Personal Versus Extrapersonal Neglect: A Group Study of their Dissociation Using a Reliable Clinical Test [J]. Cortex, 1997, 33 (2): 379-384.

[57] Fan J., He T., Hu D., et al. Advances in functional evaluation of Unilateral spatial neglect after stroke [J]. West China Medical Journal (Chinese), 2015, 30 (12): 2368-2372.

[58] Pedroli E., Serino S., Cipresso P., et al. Assessment and rehabilitation of neglect using virtual reality: a systematic review [J]. Front Behav Neurosci, 2015, 9: 226.

[59] Kim D. Y., Ku J., Chang W. H., et al. Assessment of post-stroke extrapersonal neglect using a three-dimensional immersive virtual street crossing program [J]. Acta Neurol Scand, 2010, 121 (3): 171-177.

[60] Peskine A., Rosso C., Box N., et al. Virtual reality assessment for visuospatial neglect: importance of a dynamic task [J]. J Neurol Neurosurg Psychiatry, 2011, 82 (12): 1407-1409.

[61] Buxbaum L. J., Dawson A. M., Linsley D. Reliability and validity of the Virtual Reality Lateralized Attention Test in assessing hemispatial neglect in right-hemisphere stroke [J]. Neuropsychology, 2012, 26 (4): 430-441.

[62] Fordell H., Bodin K., Bucht G., et al. A virtual reality test battery for assessment and screening of spatial neglect [J]. Acta Neurol Scand, 2011, 123 (3): 167-174.

[63] Aravind G., Darekar A., Fung J., et al. Virtual reality-based navigation task to reveal obstacle avoidance performance in individuals with visuospatial neglect [J]. IEEE Trans Neural Syst Rehabil Eng, 2015, 23 (2): 179-188.

[64] van der Kemp J., Dorresteijn M, Ten B. A., et al. Pharmacological Treatment of Visuospatial Neglect: A Systematic Review [J]. J Stroke Cerebrovasc Dis, 2017, 26 (4): 686-700.

[65] Luvizutto G. J., Bazan R., Braga G. P., et al. Pharmacological interventions for unilateral spatial neglect after stroke [J]. Cochrane Database of Systematic Reviews, 2015, 2015 (11): D10882.

[66] Marshall R. S. Rehabilitation approaches to hemineglect [J]. Neurologist, 2009, 15 (4): 185-192.

[67] Gammeri R., Iacono C., Ricci R., et al. Unilateral Spatial Neglect After Stroke: Current Insights [J]. Neuropsychiatr Dis Treat, 2020, 16: 131-152.

[68] Luaute J, Halligan P., Rode G., et al. Visuo-spatial neglect: a systematic review of current interventions and their effectiveness [J]. Neurosci Biobehav Rev, 2006, 30 (7): 961-982.

[69] Code C. Multifactorial processes in recovery from aphasia: developing the foundations for a multileveled framework [J]. Brain Lang, 2001, 77 (1): 25-44.

[70] Priftis K., Passarini L., Pilosio C., et al. Visual Scanning Training, Limb Activation Treatment, and Prism Adaptation for Rehabilitating Left Neglect: Who is the Winner?[J]. Front Hum Neurosci, 2013, 7: 360.

[71] Smania N., Bazoli F., Piva D., et al. Visuomotor imagery and rehabilitation of neglect [J]. Arch Phys Med Rehabil, 1997, 78 (4): 430-436.

[72] Pizzamiglio L., Frasca R., Guariglia C., et al. Effect of optokinetic stimulation in patients with visual neglect [J]. Cortex, 1990, 26 (4): 535-540.

[73] Robertson I H, North N. Spatio-motor cueing in unilateral left neglect: the role of hemispace, hand and motor activation [J]. Neuropsychologia, 1992, 30 (6): 553-563.

[74] Karnath H. O., Christ K., Hartje W. Decrease of contralateral neglect by neck muscle vibration and spatial orientation of trunk midline [J]. Brain, 1993, 116 (Pt 2): 383-396.

[75] Arai T., Ohi H., Sasaki H., et al. Hemispatial sunglasses: effect on unilateral spatial neglect [J]. Arch Phys Med Rehabil, 1997, 78 (2): 230-232.

[76] Rossetti Y., Rode G., Pisella L., et al. Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect [J]. Nature, 1998, 395 (6698): 166-169.

[77] Bowen A., Hazelton C., Pollock A., et al. Cognitive rehabilitation for spatial neglect following stroke [J]. Cochrane Database Syst Rev, 2013 (7): D3586.

[78] De Wit L., Ten B. A., Visser-Meily J., et al. Does prism adaptation affect visual search in spatial neglect patients: A systematic review [J]. J Neuropsychol, 2018, 12 (1): 53-77.

[79] Shiraishi H., Yamakawa Y., Itou A., et al. Long-term effects of prism adaptation on chronic neglect after stroke. [J]. NeuroRehabilitation, 2008, 23 (2): 137-151.

[80] Kashiwagi F. T., El D. R., Gomaa H., et al. Noninvasive Brain Stimulations for Unilateral Spatial Neglect after Stroke: A Systematic Review and Meta-Analysis of Randomized and Nonrandomized Controlled Trials [J]. Neural Plasticity, 2018, 2018: 1638763.

[81] Miniussi C., Cappa S. F., Cohen L. G., et al. Efficacy of repetitive transcranial magnetic stimulation/transcranial direct current stimulation in cognitive neurorehabilitation [J]. Brain Stimul, 2008, 1 (4): 326-336.

[82] Azouvi P., Jacquin-Courtois S., Luaute J. Rehabilitation of unilateral neglect: Evidence-based medicine [J]. Ann Phys Rehabil Med, 2017, 60 (3): 191-197.

[83] Kim S. B., Lee K. W., Lee J. H., et al. Effect of Combined Therapy of Robot and Low-Frequency Repetitive Transcranial Magnetic Stimulation on Hemispatial Neglect in Stroke Patients [J]. Ann Rehabil Med, 2018, 42 (6): 788-797.

[84] Yasuda K, Muroi D., Ohira M., et al. Validation of an immersive virtual reality system for training near and far space neglect in individuals with stroke: a pilot study [J]. Top Stroke Rehabil, 2017, 24 (7): 533-538.

[85] Katz N., Ring H., Naveh Y., et al. Interactive virtual environment training for safe street crossing of right hemisphere stroke patients with unilateral spatial neglect [J]. Disabil Rehabil, 2005, 27 (20): 1235-1243.

[86] Ogourtsova T., Archambault P. S., Lamontagne A. Post-stroke visual neglect affects goal-directed locomotion in different perceptuo-cognitive conditions and on a wide visual spectrum [J]. Restor Neurol Neurosci, 2018, 36 (3): 313-331.

[87] RM C E. Classification of Nursing Diagnoses: Proceedings of the Eighth Conference, North American Nursing Diagnosis Association [J]. Dimensions of Critical Care Nursing, 1990, 9 (5).

[88] Jepson R., Despain K., Keller D. C. Unilateral neglect: assessment in nursing practice [J]. J Neurosci Nurs, 2008, 40 (3): 142-149.

[89] Ohshima H., Murashima S., Takahashi R. Assessments and nursing care for right brain-damaged stroke patients: focusing on neglect and related symptoms [J]. Nurs Health Sci, 2004, 6 (2): 115-121.