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Post Stroke Risk Factors of Fall during Rehabilitation in Elderly Patients

Ashraf Thoker*

Specialist Physiotherapist Neurological Disorders, Saudi Arabia

Abstract

Aim: The present study investigated the incidence, characteristics, and risk factors predictive of falls in different patient populations hospitalized in a geriatric rehabilitation hospital.

Purpose: The aims were to evaluate evidence of risk factors for falls among patients in stroke rehabilitation and to offer recommendations for clinical practice and future research.

Method: An integrative review of the literature published from 1991 to 2020 was conducted that describes empirical investigations of risk factors for post-stroke falls during patient rehabilitation. We searched Medline, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycInfo, and Embase databases, using the search terms "accidental falls, "fall risk, "risk factors, "risk assessment, "stroke," and "cerebrovascular disorders." We extracted information regarding study design, sample, potential risk factors, analytic methods, findings, and limitations from the 20 articles that met the inclusion criteria, and was rated the level of evidence for each study.

Findings: Available empirical evidence points to impaired balance, visuospatial hemineglect, and impaired performance of activities of daily living as risk factors for falls during inpatient rehabilitation for stroke. Associations between falls and cognitive function, incontinence, visual field deficits, and stroke type were less clear, while relationships between falls and age, gender, stroke location, and impaired vision and hearing were not supported.

Conclusion: The relatively sparse literature pertaining to risk factors for falls among stroke rehabilitation inpatients indicates that deficits affecting balance, perception, and self-care significantly increase the likelihood of falls. Particularly intriguing is the less well established role of post-stroke cognition in falls in this population. A conceptual model is needed to guide scientific inquiry and clinical practice in this area. Rehabilitation professionals have long known that stroke survivors often sustain falls during their inpatient rehabilitation stay and that these falls may have catastrophic consequences. Preventing such falls is crucial, and identifying key risk factors for falls during post-stroke rehabilitation will ultimately enable clinicians to better target fall prevention efforts with patients and their families. This integrative review reveals the need for further research to better delineate the multifactorial nature of fall risk during inpatient stroke rehabilitation, with particular attention to the largely unexplored domains of cognition. Clinical

Relevance: When clinicians in the inpatient stroke rehabilitation setting evaluate which patients are at greatest risk to fall, stroke-specific risk factors such as impaired balance, visuospatial hemineglect, and self-care deficits may be better predictors than more general risk factors such as age, incontinence, and sensory impairments. Patients with these stroke-specific deficits may benefit from the use of aggressive fall prevention interventions.

Keywords: Accidental falls • Stroke • Rehabilitation

Introduction

Falls are among the most common complications of stroke [1]. Which affects 795,000 Americans annually) and results in some degree of permanent disability for an estimated 450,000 individuals [2]. Stroke-related falls occur at especially high rates in the inpatient rehabilitation setting, where incidence ranges from 20% to 48%, and nearly one-third of those who fall sustain injuries such as fractures and hematomas. Other deleterious consequences include decreased physical activity related to fear of further falls [3], decreased falls self-efficacy (the belief that one can independently ambulate without falling), and a diminished sense of dignity [4].

Considerable clinical attention has been directed toward fall prevention during inpatient rehabilitation. Nevertheless, incidence of falls and related injuries remains high. Rabadi et al. [5] reported that approximately 14% of stroke patients fell on a rehabilitation unit despite implementation of an aggressive fall prevention program, resulting in injuries that included two hip fractures and a fatal intracranial hemorrhage. Identifying stroke patients most prone to fall is necessary in order to target prevention measures appropriately, particularly since the inpatient rehabilitation environment is inherently "high risk." That is, the milieu is intentionally challenging, with clinicians pushing the limits of patients' abilities to facilitate their learning and help them achieve greater functional independence. Current science provides little direction to guide fall risk assessment in this population and setting. Efforts to identify a clinically useful set of risk factors for falls among stroke patients, regardless of setting, have been minimally successful [6-10], likely due to methodological issues of sample size and instrumentation.

Clinicians often consider age, gender, urinary incontinence, weakness, and cognitive impairment to be risk factors for falls among stroke patients, yet the scientific basis for these perceptions is unclear. In this article we provide the results of an integrative review of the empirical literature pertaining to fall risk among patients in stroke rehabilitation, and we offer recommendations for clinical practice and future research.

Timing of Falls Post Stroke

7% of falls occur in the first week after stroke.8 Post stroke studies have found that up to 37% of patients fall between 1 and 6 months 8,9 and up to 73% have fallen one year after a stroke10. Unfortunately, having had a fall is a strong indicator of the likelihood of further falls. Balance confidence and specific features of balance and gait have been closely linked in stroke survivors. Low balance confidence and higher falls risk has been demonstrated in sub-acute stroke circumstances and interventions to minimize the impact of low balance confidence have been suggested [11].

***Address for Correspondence:** Ashraf Thoker, Specialist Physiotherapist Neurological Disorders, Saudi Arabia, Tel: 966592396264; E-mail: drashraf300@gmail.com*

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Interventions to Prevent fall Specifically for Stroke Survivors

Importantly, a higher proportion of those with stroke as compared to the general population of older adults who fall sustain a hip or a pelvic fracture, 27% and <10% respectively, possible explained by loss of bone mineral density after stroke [12]. The AHA/ASA guidelines for adult stroke rehabilitation and recovery state Class IA evidence recommendations for "individuals with stroke to be provided a formal fall prevention program during hospitalization". Identifying stroke patients most prone to fall is necessary in order to target prevention measures appropriately, particularly since the inpatient rehabilitation environment is inherently "high risk." That is, the milieu is intentionally challenging, with clinicians pushing the limits of patients' abilities to facilitate their learning and help them achieve greater functional independence. Current science provides little direction to guide fall risk assessment in this population and setting. Efforts to identify a clinically useful set of risk factors for falls among stroke patients, regardless of setting, have been minimally successful [2-4], likely due to methodological issues of sample size and instrumentation.

Clinicians often consider age, gender, urinary incontinence, weakness, and cognitive impairment to be risk factors for falls among stroke patients, yet the scientific basis for these perceptions is unclear. In this article we provide the results of an integrative review of the empirical literature pertaining to fall risk among patients in stroke rehabilitation, and we offer recommendations for clinical practice and future research. The level of evidence for each study was ranked using a seven-level scale [5] ranging from Level I (systematic review or meta-analysis of all relevant randomized controlled trials, or evidence-based clinical practice guidelines based on integrative reviews) (Correction added after online publication 13-Oct-2010. Integrative review has been changed to systematic review) to Level VII (opinion of authorities and reports of expert committees). From each article, we extracted information regarding the sample size and the variables evaluated for their relationship to the occurrence of falls, as well as analytic methods, findings, and limitations. We also assessed the adequacy of information provided that would permit calculation of comparable effect sizes across studies. Further, for each potential risk factor, we noted the number of studies that found a statistically significant relationship with occurrence of falls and the number of studies showing no such statistically signifi-cant relationship. A potential risk factor was classified as having strong empirical support if a simple majority of the studies that examined the factor found a signifi-cant relationship with falls. Support was deemed weak when the majority of these studies found a nonsignificant relationship. We considered empirical support to be equivocal when the relationship between a potential risk factor and occurrence of falls was approximately evenly divided between studies with significant and nonsignificant results.

Factors with Strongest Empirical Support

Balance impairment Impaired balance, or an inability to maintain proper body position, is a common and often long-lasting consequence of stroke that affects at least twice as many stroke survivors as healthy age-matched controls [6]. It is the attribute most often associated with falls during post-stroke rehabilitation. Five studies examined impaired balance [7-11], and four found it to be significantly associated with falling. Using independent t test analyses, both Teasell's and Rabadi's groups found a significant difference in mean scores on the Berg Balance Scale (BBS) between those who fell and those who did not ($p = .009$ and $p < .001$, respectively). Similarly, using occurrence of a fall as the dependent variable, Olsson and colleagues found that impaired balance more than quadrupled the risk for falling (hazard ratio [HR] = 4.50, 95% confidence interval [CI] 1.1–18.7), and Nyberg & Gustafson noted similar results (odds ratio [OR] = 3.85, 95% CI 1.38–10.72). Although significance was found in both studies, the confidence intervals are wide and thus results must be viewed with caution. Stapleton and colleagues did not find a significant relationship between impaired balance and falls; however, this study was greatly underpowered (N=13) to detect significant associations.

Hemineglect Hemineglect, also referred to as hemi-inattention or visuoperceptual neglect, is a perceptual deficit evident when an individual fails to acknowledge half of his or her body or environment, usually due to cortical damage in the right parietal or subcortical association pathway structures [12]. Hemi neglect should not be confused with visual field deficits, which are sensory impairments caused by damage to the optic tract or the geniculostriate pathway [12,13].

Nine studies examined hemi neglect [7-11,14-16]. Three research demonstrated that hemi neglect increased the odds of falling during stroke rehabilitation by a factor of 2.1 (95% CI 1.4–2.9), 1.47 (95% CI 1.20–3.90), and 2.57 (95% CI 1.2–5.4), respectively. Nyberg and Gustafson (1997) also found that more fallers exhibited hemineglect than did nonfallers (64% *vs*. 36%; $\chi 2=10.3$, p=.001). Webster and colleagues (1995) found that patients showing either frank left-sided hemineglect, or even a preference for the right visual field, fell more often compared to either stroke patients without these visuoperceptual issues or nonstroke rehabilitation patients without neglect [$F(3,71)=6.11$; $p<.001$]. The remaining four studies revealed no relationship between hemineglect and falls.

Self-Care deficit Six studies identified various aspects of self-care deficit, or impairment in the ability to attend to one's daily needs, as significantly and positively associated with post-stroke falls [4,7,14-19]. and colleagues found a significant relationship between falls and transfer ability ($p<.001$), but not between falls and a more general conceptualization of self-care operationalized by summing the scores for 13 motor self-care items encompassing activities of daily living (ADLs), transfers, elimination, and locomotion on the Functional Independence Measure [20]. Other investigations revealed signifi-cant relationships between general measures of self-care, including total and motor FIM scores, the Barthes Index, the Katz Index, and the Sister Kenny Self-Care Evaluation. The odds of falling when self-care was impaired ranged from 2.59 (95% CI 1.24–5.42) to 8.9 (95% CI 4.8–16.4 [7,14,18,19] and mean ADL performance scores were significantly different between fallers and nonfallers, ranging in significance from $p<.001$ [4,15,18].

Factors with Equivocal Empirical Support

Cognitive impairment Cognitive impairment is common after stroke [20,21] and patients with cognitive deficits may attempt actions beyond their capabilities, forgetting that their condition renders them unable to ambulate, transfer, or perform other self-care safely without assistance. Three studies demonstrated a positive association between post-stroke cognitive impairment and falls, with p levels ranging from .05 to .001 [7,9,11,18], whereas four studies found no such relationship et al. Impulsivity, a component of impairment in the executive function domain of cognition, received attention in only one study. Although Rapport et al. (1993) found no significant relationship between general cognitive ability and falls in their small sample (N = 32), they demonstrated that one measure of behavioral impulsivity (i.e., failure to inhibit looking at a monitor until presented with a defined cue) was moderately associated ($r = .48$, $p < .003$).

Hemiparesis-motor impairment Three of six studies found significant differences in hemiparesis-motor impairment scores between fallers and nonfallers, including Rabadi et al. $p = .03$; Sze et al. (2001), $p = .029$ and Teasell et al. [11], (Correction added after online publication 13-Oct-2010. The p value has been updated p = .013–.016. Czernuszenko & Czlonkowska [14] found that hemiparesis increased the risk for falling by 40% (OR = 1.4, 95% CI 1.0–1.8), although this finding must be viewed with caution since the confidence interval included 1.0. The remaining studies [8] failed to find a significant association.

Factors with Weak or No Support

Several factors examined in the 14 investigations included in this review had little or no association with falls. For example, all five studies [7,8,14] investigating relationships between falls and medications such as opioid analgesics, antihypertensives, antiarrhythmics, laxatives, and diuretics revealed no statistical association, although Czernuszenko & Czlonkowska [14] found that subjects taking antidepressant medications had slightly greater odds for falling (OR = 1.3, 95% CI 1.0–1.74), though the confidence interval includes 1.0. Nyberg & Gustafson [7] found urinary incontinence to be significantly associated with falls (OR=4.05, 95% CI 1.72–9.52), but two other research teams [8] did not. Findings were likewise equivocal across studies for the relationship between falls and stroke type; homonymous hemianopsia, or visual field deficit; apraxia, or the inability to complete motor movements despite lack of a neuromuscular deficit; attention; and generalized visuoperceptual deficit (non-neglect).

Other factors with little or no support as indicators of fall risk during inpatient rehabilitation for stroke included age, gender, stroke location, communication ability, comorbidities such as heart disease and depression, mobility impairment, social cognition (i.e., the ability to perceive and understand social situations and successfully engage in interpersonal interactions; [22], impaired visual or hearing acuity, history of falls, postural hypotension, gait impairment, and response time. The combination of impaired balance, hemineglect, and male gender was also found to be nonsignificant [8].

Discussion

Our integrative review of the empirical literature pertaining to inpatient stroke rehabilitation points to numerous factors that may influence falls in this population and setting. The relatively sparse evidence in this area varies in its support for the role of selected demographic variables, current health status, medications, functional and sensory deficits, cognitive and perceptual impairments, and physical capabilities in the occurrence of falls. Support is strongest for balance impairment, hemineglect, and deficits in performing self-care activities, with equivocal results for cognitive impairment, hemiparesis, and motor impairment, and little evidence that many of the risk factors empirically linked to falls in the elderly pertain to our target population.

Variations in terminology, instrumentation, eligibility criteria, and site characteristics across the studies we reviewed warrant careful consideration. In some instances, consistent findings for potential risk factors resulted when the same or similar measures were used despite differences in variable labels. In other instances, risk may have been undetected or underestimated due to use of inadequately sensitive measures or lack of representativeness in the sample. Investigations of the role of balance impairment in falls illustrate this point. Though variable names for impaired balance differed (e.g., "postural stability" vs. "balance") among studies that evaluated this potential risk factor, all of these studies used the BBS or the balance subscale of the Brunnstrom-Fugl-Meyer Scale. The latter measure assesses sitting and standing balance in a variety of static positions [3], while the BBS assesses balance during sitting and standing activities that include reaching and bending over [11]. Because the BBS assesses both static and dynamic activities, it may provide more clinically meaningful information for planning therapeutic activities as well as permit better prediction of persons likely to fall in the acute rehabilitation setting.

A key limitation of three of the studies examining impaired balance [7-11] is that bedridden or immobile patients were excluded, even though stroke patients often sustain falls from bed. Indeed, "immobile" patients in acute rehabilitation would likely still be participating in therapeutic activities such as bed-to-chair and bedto-toilet transfers, and these activities are often associated with falls [4,9,11,14,23]. Similarly, excluded patients who died during rehabilitation, which may have obscured important information, particularly if death resulted from a fall.

Methodologic weaknesses in instrumentation and sample size may have also contributed to nonsignificant findings in four of the nine studies focused on hemineglect. Two of these studies were underpowered to detect a significant relationship [10,16] and a third study relied on clinician judgment rather than objective measurement to ascertain hemi neglect [11]. The fourth study [15] measured hemi neglect as a composite of clinician ratings plus several tests including the Line Bisection Test, a letter cancellation task [24], or the Motor-Free Visual Perceptual Test (MVPT; Colarusso rather than a single validated test. Clinician ratings may be of questionable reliability and validity, and disagreement prevails regarding the most clinically valid objective test for assessing hemineglect. Letter cancellation tasks may be artificially simplistic and thus not a valid measure of visuospatial hemineglect. The MVPT, which tests general visual-perceptual ability, is likewise not suited for measuring this construct [25.] Thus, it appears that the utility of hemineglect in assessing risk for falling may hinge on the instrument used to measure this construct.

Findings for self-care deficit may have been similarly influenced by the operational definition of "self-care" used in each study that examined this potential risk factor, which was variously measured using the FIM, the Barthel Index, the Katz Index, or the Sister Kenny Self-Care Evaluation. Further, sample selection bias may have been introduced when patients rehospitalized during their rehabilitation stay were excluded from some of these retrospective studies. An estimated 10% to 20% of stroke rehabilitation inpatients require rehospitalization, and these individuals tend to exhibit lower self-care abilities than their nonrehospitalized counterparts [26]. We surmise that studies excluding less capable stroke patients likely had decreased variability in self-care across samples and similarly underestimated the contribution of deficits in self-care to falls. Thus, the true relationship between self-care and falls may be even more pronounced. Lack of consistent definitions of hemiparesis and motor impairment, with no clearly accepted measurement of these constructs, may have contributed to the mixed results for these potential risk factors. Heterogeneity or lack of sensitivity among cognitive measures may likewise have figured into the equivocal support demonstrated across studies for cognitive impairment. For example, several investigators used global cognitive screening or dementia screening tests such as the Abbreviated Mental Test [19,27] or the Fromstein Mini-Mental State Examination [7,9]. Other researchers relied on the cognitive FIM score [11,18], whereas Rapport and colleagues [4] used nurses' ratings to assess a variety of cognitive abilities including general cognitive ability, attention, impulsivity, and ability to perform a similarities task requiring abstract thought. While many of these measures are used clinically to assess dimensions of cognition, the method used by these investigators to measure impulsivity is not, which limits the applicability of their findings.

Many of the potential risk factors for which our integrative review revealed little or no empirical support have not been well studied, often having been examined in only one or two investigations. Findings for broadly defined factors such as "medications" or "comorbidities" may also have been inconsistent across studies due to variation in their operational definitions. In addition, several studies excluded patients with severe aphasia, which likely decreased the heterogeneity of the sample and limited the inferences that could be made regarding the role of impaired communication in falls. It is noteworthy that in the literature regarding community-dwelling older adults, several of these factors (e.g., medications, visual problems, and urinary incontinence) are accepted risk factors for falls [28,29]. However, in the stroke rehabilitation population these factors do not appear to identify potential fallers.

No association between post-stroke cognition and falls was found in studies conducted at sites with already existing aggressive fall prevention programs, which may have confounded the results due to heightened staff vigilance and use of fall prevention measures for all cognitively impaired patients [16,19]. Even at sites without such aggressive programs, the research project alone may have prompted increased staff vigilance and prevention efforts, thereby decreasing falls among cognitively impaired stroke patients [27]. Most of the research reports reviewed here employed a "shotgun" approach, investigating numerous potential correlates of falling, often without clear empirical or theoretical grounds for inclusion of the particular array of variables studied. Results of this review suggest that impaired balance, hemineglect, and ADL performance impairment are strongly associated with falls, and occur frequently in persons with stroke. Only two studies [7,8] included all three of these risk factors, and only one study considered how the combination of balance impairment, hemineglect, and male gender related to falls. Our results indicate that future research is needed to explore the extent to which balance impairment, hemineglect, and self-care deficits together explain variability in the occurrence of falls among inpatients engaged in stroke rehabilitation. Likewise, multivariate meth ods should be employed to determine the amount of explained variance in falls when factors with mixed or moderate empirical support, such as selected medications, urinary incontinence, visual field deficits, apraxia, inattention, and general cognitive impairment, are included in the analysis. This would be consistent with the approach used by researchers who have identified risk factors for falls among older adults in both home and acute hospital environments [28,29,30] Further, such an approach would enable refinement of fall prediction and development of tailored fall prevention programs in the rehabilitation setting.

More nuanced understanding of cognitive impairment in relation to falls during inpatient rehabilitation is needed, especially given the multiple cognitive

domains that may be affected by stroke and the mixed results pertaining to post-stroke cognition found in this review. Tests of general cognitive ability used in most studies yielded mixed results, while executive dysfunction, the most common post-stroke cognitive impairment [31] affecting 50% of stroke survivors [32] was assessed in only one study, and then only with a measure of impulsivity, which was strongly associated with falls. Executive function entails higher-order cognitive processes that control, integrate, and organize other cognitive abilities. In contrast, executive dysfunction is manifested by disinhibition; impaired ability to think abstractly or synthesize information; verbal or motor perseveration; inability to shift from one task, behavior, or construct to another; and difficulty sequencing thoughts and actions [33]. Liu-Ambrose, Pang, and Eng [34-38] have demonstrated that executive function is independently associated with both balance and mobility among community-dwelling stroke survivors. Further research is needed to elucidate the as yet unclear relationships between executive cognitive function and falls. Formulation of a conceptual model of factors that contribute to falls during inpatient rehabilitation would help to guide future research and could also inform treatment strategies to prevent falls [39-41].

Developing a simple model for fall risk assessment that includes two or three predictors would particularly appeal to busy clinicians, and one such model has been trialed [42-45] on a mixed-diagnosis rehabilitation unit. After noting that 17% of the variability in falls on their unit was explained by mobility impairment and impaired problem solving, Gilewski and colleagues implemented fall prevention measures (primarily increased vigilance by staff) with individuals who exhibited these impairments [46-48]. The result was a clinically desirable but not statistically significant reduction in the occurrence of falls, from 6.6 falls per 1,000 patient days to 5.7 falls per 1,000 patient days. Future research using a similarly parsimonious model that is informed by the results of this integrative review may account for a greater proportion of explained variance in falls among stroke rehabilitation inpatients [49-51].

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