The Pattern of Recovery of Ambulation After Hip Fracture Differs With Age in Elderly Patients

F. Javier Ortiz-Alonso, Maite Vidán-Astiz, Mar Alonso-Armesto, Miriam Toledano-Iglesias, Loreto Alvarez-Nebreda, Fatima Brañas-Baztan, and Jose A. Serra-Rexach

Geriatric Service, Hospital General Universitario Gregorio Marañon, Madrid, Spain.

Address correspondence to F. Javier Ortiz Alonso, MD, Geriatric Service, Hospital General Universitario Gregorio Marañon, Doctor Esquerdo, no. 46, Madrid 28007, Spain. Email: jortiz.hugm@salud.madrid.org

Background. The main objective of this study was to analyze the independent effect of increasing age on the recovery of different areas of functioning 1 year after hip fracture.

Methods. Consecutive 1-year survivors aged ≥65 years (n = 362) admitted to a single hospital for acute hip fracture surgery were followed prospectively for 1 year. Age was stratified as <75, 75–84, and ≥85 years. Basic activities of daily living and ambulation were measured by personal interview during hospitalization and phone contact at 3, 6, and 12 months. Longitudinal data of recovery in these areas were analyzed using generalized estimating equations.

Results. Older age was strongly associated with poor recovery in all areas of function, except eating. The pattern of recovery of ambulation differed with age, peaking at 6 months in the younger group and continuing for at least 12 months in the eldest group. The pattern of recovery of overall and individual activities of daily living was similar in the three age groups. Recovery of areas associated with upper extremity function peaked at 3 months, whereas areas associated with lower extremity function peaked at 6 months.

Conclusions. The patterns of functional disability after hip fracture differ with areas of function and age with the oldest patients having a particular risk of decline and a prolonged time to recovery of ambulation.

Key Words: Hip fracture—Ambulation recovery—Aging.

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ip fracture is a major public health problem in most countries because of its prevalence, difficult management, and economic cost. Despite the documented decrease in the incidence of hip fracture in the United States and Canada (1,2), incidence in Spain has remained essentially unchanged (3). Between 20% and 30% of older hip fracture patients die within 1 year of their injury (4–7). In patients who survive, the injury has significant effects on functioning. Depending upon the population studied and the area of functioning, between 20% and 90% of patients develop new disabilities within 1 year (4–6,8–11).

Advanced age is associated with poor recovery of function after hip fracture (9,12–14). However, few studies have investigated the specific relationship between age and recovery in different areas of function. Although most functional recovery occurs by 6 months, recovery continues for more than 1 year in some areas (6,9–11,14–16), and the time to recovery may differ with age. The generally accepted opinion that the effect of age is similar in the recovery of all areas of function may be inadequate. Some patients experience secondary losses after initial recovery (9,10), and this subsequent decline may be related to advanced age. It has been suggested that older patients are slow to regain physical function after hip fracture (6) and has been shown that, with intensive physical therapy, hip fracture persons over 90 years may have favorable outcomes (17). Therefore, possible age differences in functional recovery may affect decisions on therapy and rehabilitation after hip fracture.

We performed a longitudinal analysis of data collected at three time points after hip fracture to study patterns of recovery in different areas of functioning. Our primary objective was to study the independent effect of increasing age on the recovery of different areas of functioning. We hypothesized that time to recovery of different areas of functioning is slower in the oldest patients. Our secondary objective was to identify the time to maximum recovery in each area of function.

METHODS

Patients

Patients were selected from two sources: a randomized controlled trial (RCT) of a geriatric intervention in elderly patients hospitalized for hip fracture (4) conducted during 1997 and 1998 and a subsequent cohort of hip fracture patients studied between March 1999 and January 2001.
Because functional recovery after hospital discharge was similar in the intervention and control groups in the RCT, all patients were combined for this analysis. At baseline, patients from the two sources, RCT and the cohort study, were of comparable age. Patients from the RCT have a mean score slightly higher on the physical activities of daily living (PADLs) scale (4.91 vs 4.59) and lower on the ambulation scale (4.32 vs 4.59). The reference population included all 538 patients aged 65 years and older admitted to Hospital Gregorio Marañón (Madrid, Spain) for acute hip fracture surgery. This study included only 1-year survivors. The exclusion criteria were as follows: dependency in all PADLs and being bedridden before the fracture; pathological hip fracture; known terminal illness, defined as life expectancy less than 12 months; and refusal to participate. Of the 538 patients, 21 were excluded because of dependency in all PADLs and being bedridden at baseline and 125 died during the year of follow-up, leaving an eligible population of 392 patients. Of these, 30 were lost to follow-up during the year after fracture. The remaining 362 patients were included in this analysis. The study was approved by the institutional review board, and informed consent was obtained from patients or proxies.

Rehabilitation and discharge practices of the patients: During the RCT, rehabilitation practices included inpatient rehabilitation (during the acute care or discharged to a close rehabilitation facility) or in long-term institutional care. During the RCT, 68% of the patients in the control group and 89% in the intervention group had some inpatient rehabilitation. After the RCT, we implemented an orthogeriatric model of care. In this model, rehabilitation and discharge practices vary: First, patients from home, mentally well, and mobile postoperatively are most likely to be discharged home with support, with or without inpatient rehabilitation during the acute care (32% of the patients in the cohort study); second, patients with comorbidities and poor baseline functional status are most likely to undergo rehabilitation in an inpatient geriatric orthopedic rehabilitation unit of the hospital (58% of the patients in the cohort study); third, patients from institutional care are most likely to undergo rehabilitation in their institution. Prolonged rehabilitation is not widely used, except in skilled nursing facilities.

Data Collection

Data were obtained using interviews and medical records. Baseline assessment took place on admission through interviews with each patient or a caregiver when the patient was not mentally aware. Data on functional level 2 weeks before hospital admission were considered baseline data. The patient and patient’s primary nurse were also interviewed at discharge, and the patient and caregiver were contacted by phone to assess functional level at 3, 6, and 12 months after hip fracture. Medical records were reviewed to ascertain type of fracture and repair, presence of chronic medical conditions, and postoperative medical and surgical complications.

Outcome Measures

The major outcome variables used in the study were recovery of the ability to function in performing six basic PADLs (bathing, dressing, using the toilet, transferring from bed to chair, continence, and eating) and the ability to walk at 3, 6, and 12 months after hip fracture. For each PADLs, a score of 0 was assigned for complete dependence and 1 for independence, as described by Katz and colleagues (18). A summary scale was constructed by summing the individual PADLs (range of 0–6). Ability to walk was defined using the Functional Ambulation Classification (19) as one of six functional levels of ambulation: A score of 0 was assigned if the patient could not walk, 1 if the patient required continuous manual contact to support the body, 2 for light or intermittent manual contact to assist balance, 3 for independent but supervised ambulation, 4 for independent ambulation on level surfaces but supervision or physical assistance on stairs, and 5 for independent ambulation on level surfaces and stairs. For both of these outcomes, recovery was defined as performance that was at least as good at the three follow-up times (3, 6, and 12 months) as before the fracture. Recovery was also analyzed for each individual PADLs in patients who were independent in a particular PADLs at baseline.

Predictor Measures

The categories of independent variables included were sociodemographic characteristics, baseline health and functional status, type of fracture and repair, postoperative medical and surgical complications, health care utilization, and discharge disposition. Demographic characteristics included age, gender, education, marital status, and residence before the fracture (dichotomized as home or nursing home). Baseline health and functional status included level of independence in PADLs, ability to walk, and chronic medical conditions (heart disease, hypertension, stroke, diabetes mellitus, dementia, cancer, arthritis, and chronic obstructive pulmonary disease). Chronic conditions were examined individually and dichotomized as having any one or none of them. Type of fracture was dichotomized as subcapital or per-subtrochanteric, and surgical repair was dichotomized as prosthetic replacement or internal fixation. Postoperative medical complications were examined individually and dichotomized as any one or none of the following: delirium, congestive heart failure, pneumonia, deep vein thrombosis, pulmonary embolism, pressure sore, urinary tract infection, and myocardial infarction. Delirium was assessed using the confusion assessment method (20). Postoperative surgical complications were examined individually and dichotomized as any one or none of the following: wound infection, prosthesis dislocation, or reintervention. Health care utilization referred to length of stay and discharge was grouped into discharge home, discharge to a nursing home, or discharge to a rehabilitation facility. Readmissions to the hospital or the emergency department were also registered.
### Table 1. Baseline and Fracture Characteristics and In-Hospital Outcomes for the Total Group and by Age Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (N = 362)</th>
<th>Age ≤ 74 (n = 77)</th>
<th>Age 75–84 (n = 161)</th>
<th>Age ≥ 85 (n = 124)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y), M ± SD</td>
<td>81 ± 7</td>
<td>70 ± 3</td>
<td>80 ± 3</td>
<td>89 ± 3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>306 (85)</td>
<td>61 (79)</td>
<td>132 (82)</td>
<td>113 (91)</td>
<td>.015</td>
</tr>
<tr>
<td>Widowed, n (%)</td>
<td>218 (60)</td>
<td>27 (35)</td>
<td>92 (57)</td>
<td>99 (80)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Living at home, n (%)</td>
<td>325 (90)</td>
<td>64 (83)</td>
<td>108 (67)</td>
<td>56 (73)</td>
<td>.015</td>
</tr>
<tr>
<td>No. of coexisting conditions, M ± SD</td>
<td>2.7 ± 1.4</td>
<td>2.5 ± 1.6</td>
<td>2.8 ± 1.4</td>
<td>2.6 ± 1.4</td>
<td>.418</td>
</tr>
<tr>
<td>Conditions, n (%)</td>
<td>Dementia</td>
<td>69 (19)</td>
<td>4 (5)</td>
<td>27 (17)</td>
<td>38 (31)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>65 (18)</td>
<td>20 (26)</td>
<td>30 (19)</td>
<td>15 (12)</td>
<td>.043</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>75 (21)</td>
<td>18 (23)</td>
<td>35 (22)</td>
<td>22 (18)</td>
<td>.576</td>
</tr>
<tr>
<td>COPD</td>
<td>41 (11)</td>
<td>13 (17)</td>
<td>22 (14)</td>
<td>6 (5)</td>
<td>.015</td>
</tr>
<tr>
<td>No. of medications, M ± SD</td>
<td>2.6 ± 1.9</td>
<td>2.5 ± 1.9</td>
<td>2.9 ± 2.1</td>
<td>2.4 ± 1.6</td>
<td>.054</td>
</tr>
<tr>
<td>Independent ambulation1, n (%)</td>
<td>214 (59)</td>
<td>60 (78)</td>
<td>102 (63)</td>
<td>52 (42)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Independent in individual PADLs2, n (%)</td>
<td>Bathing</td>
<td>234 (65)</td>
<td>64 (83)</td>
<td>115 (71)</td>
<td>55 (44)</td>
</tr>
<tr>
<td>Dressing</td>
<td>316 (87)</td>
<td>71 (92)</td>
<td>144 (89)</td>
<td>101 (82)</td>
<td>.05</td>
</tr>
<tr>
<td>Toileting</td>
<td>306 (85)</td>
<td>73 (95)</td>
<td>142 (88)</td>
<td>91 (73)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Transferring</td>
<td>319 (88)</td>
<td>70 (91)</td>
<td>146 (91)</td>
<td>103 (83)</td>
<td>.063</td>
</tr>
<tr>
<td>Continence</td>
<td>204 (56)</td>
<td>60 (78)</td>
<td>84 (52)</td>
<td>60 (48)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Feeding</td>
<td>357 (99)</td>
<td>77 (100)</td>
<td>159 (99)</td>
<td>121 (99)</td>
<td>.150</td>
</tr>
<tr>
<td>Type of hip fracture, n (%)</td>
<td>Subcapital</td>
<td>164 (45)</td>
<td>44 (57)</td>
<td>67 (42)</td>
<td>53 (43)</td>
</tr>
<tr>
<td>Per-subtrochanteric</td>
<td>198 (55)</td>
<td>33 (43)</td>
<td>95 (58)</td>
<td>71 (57)</td>
<td>.089</td>
</tr>
<tr>
<td>Type of surgery, n (%)</td>
<td>Prosthetic replacement</td>
<td>107 (30)</td>
<td>15 (20)</td>
<td>53 (33)</td>
<td>39 (32)</td>
</tr>
<tr>
<td>Internal fixation</td>
<td>255 (70)</td>
<td>62 (80)</td>
<td>108 (67)</td>
<td>85 (68)</td>
<td></td>
</tr>
<tr>
<td>Postoperative complications, n (%)</td>
<td>Any medical complication</td>
<td>203 (56)</td>
<td>30 (39)</td>
<td>84 (53)</td>
<td>89 (72)</td>
</tr>
<tr>
<td>Delirium</td>
<td>113 (31)</td>
<td>10 (13)</td>
<td>43 (27)</td>
<td>60 (48)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Inpatient rehabilitation, n (%)</td>
<td>283 (78)</td>
<td>56 (73)</td>
<td>130 (81)</td>
<td>97 (78)</td>
<td>.375</td>
</tr>
<tr>
<td>Length of stay (days), M ± SD</td>
<td>15.9 ± 6.9</td>
<td>15.1 ± 6.1</td>
<td>15.7 ± 6.3</td>
<td>16.7 ± 8.0</td>
<td>.258</td>
</tr>
</tbody>
</table>

Notes: COPD = chronic obstructive pulmonary disease; PADLs = physical activities of daily living.
* p values are drawn from linear effects of an analysis of variance (continuous variables) and the chi-square test (dichotomous variables) between age groups.
1 Independent ambulation was considered a walking ability classified as Grade 5 of the Functional Assessment Classification.
2 The six basic PADLs were bathing, dressing, transferring, toileting, continence, and feeding.

### Data Analysis

Data were organized using frequency distributions, summary statistics, and univariate analysis. Age was stratified into three different categories (<75, 75–84, and ≥85 years), and baseline differences between age groups were compared using linear effects in an analysis of variance (continuous variables) and a chi-square test (dichotomous variables). The recovery rate of PADLs and ambulation were calculated at the three follow-up times. To document partial recovery of PADLs and ambulation, the means and SDs for the continuous scales of PADLs and ambulation were also calculated. These continuous scales could illustrate what is happening to patients who do not fully recover. To explore differences in recovery over time and identify the follow-up month of maximum recovery for each aspect of functional status, longitudinal data were analyzed using generalized estimating equations (GEEs) and SPSS version 15.0 (SPSS Inc., Chicago, IL). The GEE approach takes into account possible correlations in repeated measures over time. The GEE model specification assumes that recovery has a binomial distribution. A logit function (logarithm of the odds of recovery) relates the probability of recovery to a linear combination of predictors. An unstructured correlation matrix, with no restrictions on the correlations, was specified because there are many clusters (patients), few time points, and no missing data. The sandwich variance estimator was used to obtain robust standard error estimates. To explore differences in the recovery of different areas of function by age group, an interaction term was constructed between age group and time. Predictors of functional recovery were first explored by univariate analysis. The significant predictors (p < .05) included in the final GEE model were age (stratified into three groups), time of follow-up (3, 6, and 12 months post-fracture), presence of dementia, prefracture PADLs and walking ability, and presence of postoperative medical complications.

### Results

#### Patient Characteristics

Descriptive statistics of baseline characteristics, hip fracture data, and in-hospital outcomes for the whole group and by age groups are shown in Table 1. Advanced age was associated with differences in socio-demographic characteristics and comorbid conditions and with greater levels of functional dependence before admission and postoperative medical...
Table 2. Absolute Independence in PADLs and Ambulation at Baseline and 3, 6, and 12 Months After Surgery by Age Groups*

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>PADLs†</th>
<th>Ambulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>3 mo</td>
</tr>
<tr>
<td>Total (N = 362)</td>
<td>4.80 (1.47)</td>
<td>3.75 (2.03)</td>
</tr>
<tr>
<td>≤75 (n = 77)</td>
<td>5.39 (1.07)</td>
<td>5.12 (1.51)</td>
</tr>
<tr>
<td>75–84 (n = 161)</td>
<td>4.91 (1.40)</td>
<td>3.89 (1.83)</td>
</tr>
<tr>
<td>≥85 (n = 124)</td>
<td>4.28 (1.62)</td>
<td>2.72 (2.01)</td>
</tr>
</tbody>
</table>

Notes: †Entries are M (SD) for the continuous scales of PADLs and ambulation. The PADLs scale ranges from 1 to 6 and the ambulation from 0 to 5.
†PADLs = physical activities of daily living. The six basic PADLs were bathing, dressing, transferring, toileting, continence, and feeding.
in the recovery of ambulation between the three age groups. Patients younger than 75 years improved significantly from 3 to 6 months and remained stable until 12 months. Patients over 85 years showed no improvement from 3 to 6 months but improved from 6 to 12 months. The intermediate age group continued to improve ambulation from 3 to 12 months (Figure 3).

The progress of individual PADLs by age groups using GE modeling is shown in Figure 4. The pattern of recovery of the individual PADLs was similar in the three age groups. Older age was associated with poor recovery in all the PADLs, at each follow-up time, except for feeding, which was not affected by age or hip fracture. In the three age groups, recovery in bathing and transferring improved in the first 6 months and then remained stable and recovery in dressing and toileting only improved in the first 3 months and was stable thereafter. In the two older groups, continence declined after 6 months. Excluding feeding, after 1 year, recovery ranged from 88% (bathing) to 92% (dressing) in patients younger than 75 years and from 41% (bathing) to 61% (dressing) in patients aged 85 years and older.

**Discussion**

We studied functional recovery in a cohort of survivors after hip fracture. After 1 year, slightly over half (53%) had recovered physical function as measured by PADLs and ambulation. The degree and rate of recovery vary by areas of function and age. Recovery overall and of most of the individual PADLs peaked at 3 months of follow-up, whereas recovery in ambulation continued to improve until 12 months. Older age was strongly associated with poor recovery of both PADLs and ambulation. The pattern of recovery of ambulation differed between age groups: Recovery in the youngest patients peaked at 6 months, but recovery in the oldest groups continued for 12 months. There were no age differences in the pattern of recovery of overall and individual PADLs. Therefore, these findings confirm only our original hypothesis that the oldest age is associated with a longer time to recovery of ambulation, but not of PADLs. Of the patients who recovered baseline ambulation at 1 year, recovery took more than 6 months in 32% of the eldest group and only 8% of the youngest group. The interpretation of these findings may be multifactorial. First, very old persons are more likely to show a prolonged time to recovery of ambulation after hip fracture due to a slower return to homeostasis following injury or acute medical problems because of underlying frailty and its reduced physiologic capacity (21), low bone mineral density (22), and low levels of vitamin E (23) that have recently been described after hip fracture. Second, the recovery from hip fracture is superimposed on the disableness process already existing at the time of the fracture (6,9), and advanced age and muscle impairment in lower extremity are predictive of this disableness process (24,25). Therefore, it is possible that hip fracture may alter the disableness process in a different way in different age groups.

Several reports examine recovery of ambulation in the oldest patients (6,16,17,26–31). However, among the aged, few studies have compared the recovery between “young elderly” (age lower than 85 years) and “oldest old” (age 85 and older [6,16,26–28,30]), and only one study (6) has investigated the specific relationship between age and time to recovery of ambulation after hip fracture. The authors found that the oldest patients appeared to require a longer time to recovery. However, contrary to our findings, the oldest patients achieved the same functional recovery after 1 year as the younger patients. Comparison of these results is difficult because of differences in outcome measures, study population, and analysis.
These findings have important implications because they suggest that older patients with hip fracture may need either more intensive rehabilitation to accelerate recovery of ambulation or the continuation of rehabilitation for longer periods. This issue has been addressed previously \((17)\) in patients aged over 90 years. With intensive physical therapy, the authors found that 62.5% of survivors gained independent ambulation and, after 1 year, almost all continued ambulation. These results are within the range of the ambulation predicted for the younger groups in our study.

Data from our study also describe the recovery of overall and individual PADLs following hip fracture. We found that dressing, a PADL associated with upper extremity function, reached peak recovery during the first 3 months postfracture, whereas bathing and transferring, tasks associated with lower extremity function, reached peak recovery in the first 6 months. Therefore, the more complex the individual PADLs, the longer it takes to recover after hip fracture. This recovery sequence is similar to that described in previous studies \((6,9–11)\) and, as stated by Magaziner and colleagues \((10)\), “parallels the process of disablement proposed by Verbrugge and Jette” \((32)\). In the present study, age was strongly associated with poor recovery of overall and individual PADLs, although the pattern of recovery of PADLs was not affected by age.

Patients included in the analysis came from two sources, an RCT and a cohort study. Although rehabilitation may differ slightly in both groups, the proportion of patients with inpatient rehabilitation was 78% in both groups, and both the proportion of patients who received inpatient rehabilitation...
(Table 1) and the number of days in rehabilitation (data not shown) were comparable in the three age groups. Furthermore, the results of the GEE modeling limited to the patients of the RCT reproduce the findings of the whole population.

Our study has several potential limitations. First, the functional evaluation of the individual physical PADLs was based on the Katz Index with a dichotomous response indicating complete independence or not. It is possible that no changes were detected in individual PADLs recovery among groups because the instrument lacks sensitivity to detect subtle changes over time. Second, data were not available on long-term rehabilitation services or recurrent hospitalization, with the result that the impact of this issue on functional recovery could not be evaluated. However, prolonged rehabilitation is not widely used, except in skilled nursing facilities, and the proportion of patients institutionalized after 1 year was higher in the eldest group. Third, it was not possible to consider all potential predictors of recovery, including depression (33–35) and pain (36,37); therefore, the impact of these potential predictors on functional recovery could not be evaluated. Fourth, the data on outcomes were collected in the late 1990s and early 2000s; however, there is no reason to expect that the management of hip fracture and the functional recovery after it have changed. Fifth, this is a single-site study that was limited to the healthiest survivors; consequently, the findings may not apply to all patients with hip fracture. Finally, another potential problem of generalizing results is the losses to follow-up. At baseline, they were of comparable age but with a slightly poorer functional status (mean score in the PADLs [4.05 vs 4.43] and ambulation scales [4.28 vs 4.79]). However, they were only 7.6% of the eligible population, and baseline function was controlled for in the analysis.

Despite these limitations, we provide new information on the effect of age on the recovery of ambulation and PADLs after hip fracture. Older age is strongly and independently associated with poor recovery of both ambulation and PADLs. Although there are no age differences in the pattern of recovery of overall and individual PADLs, the pattern of recovery of ambulation differed between age groups, with the oldest old patients having a prolonged time to recovery of ambulation. Although these findings will need to be confirmed in other studies, these results illustrate the need for improved rehabilitation in the oldest old and provide information for designing interventions and rehabilitation programs that extend longer than the immediate postacute period.

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**References**


