Changes in Functional Status Attributable to Hip Fracture: A Comparison of Hip Fracture Patients to Community-dwelling Aged

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Disability attributable to hip fracture regarding activities of daily living was evaluated by comparing 594 hip fracture patients entering eight hospitals in Baltimore, Maryland, in 1990–1991 with community-dwelling aged from the Established Populations for Epidemiologic Studies of the Elderly (EPESE) cohort matched on age, sex, and walking ability. Subjects were assessed at baseline (prefracture report for patients), 12 months, and 24 months. At baseline, 26% of both groups had walking disability, 12–14% had transferring disability, and 6–8% evidenced grooming disability. At 12 and 24 months, about 50% of hip fracture patients were walking disabled compared with 21–29% of EPESE respondents after the authors controlled for age, sex, comorbidities, and functional status (excess disability attributable to hip fracture, i.e., attributable disability, of 26 additional cases of disability per 100 persons in the hip fracture cohort during follow-up). Likewise, hip fracture patients experienced more disability regarding transferring (38–39% vs. 10–18%; attributable disability, approximately 22 cases per 100 persons) and grooming (17–19% vs. 7–15%; attributable disability, approximately six cases per 100 persons). Thus, results showed that hip fracture patients had substantially more activities of daily living disability than that explained by aging over 24 months.

activities of daily living; aging; disability evaluation; disabled persons; hip fractures

Abbreviations: ADL, activities of daily living; BHS, Baltimore Hip Studies; EPESE, Established Populations for Epidemiologic Studies of the Elderly.

Hip fracture is a major public health problem because of its prevalence, economic costs, and health consequences. Approximately 340,000 persons in the United States older than age 65 years fracture a hip each year (1), and the estimated annual cost is more than $8.5 billion (2–4); by 2040, over 650,000 hip fractures will occur annually in this population (5). Between 18 percent and 33 percent of older hip fracture patients die within 1 year of their fracture (6–19). In addition, an estimated 25–75 percent of those who were independent before their fracture can neither walk independently nor achieve their prefracture level of independent living a year after fracture (6, 20–25).

Despite changes in functioning after hip fracture, the extent to which these changes can be attributed to the fracture remains uncertain; identifying this excess loss is important for understanding the level of recovery that can be expected following a fracture. Several studies (20–22, 24, 25) have reported increased impairment in physical and instrumental functioning relative to prefracture status for as long as 2 years after fracture. However, these studies lacked comparison groups and could not evaluate how much of the functional decline was due to the hip fracture and how much would have occurred in this vulnerable population even without fracture.

Three cohort studies of community-dwelling aged evaluated changes in functional status among respondents who fractured a hip compared with those who had not (26–28). These studies found that, over follow-up periods of 6 months to 6 years, hip fracture patients had greater losses regarding activities of daily living (ADL) than same-aged persons who...
had not fractured a hip. Although these studies provide more evidence for functional impairment resulting from hip fracture than studies without comparison groups, they lack information on functional status immediately prior to the fracture and therefore cannot be used to determine how much of the observed decline preceded the fracture and how much followed it. Ideally, functional status should be measured just prior to the fracture and at multiple time points afterwards as well as at similar intervals for a comparison group. Functional status around the time of hip fracture can be assessed more accurately by identifying hip fracture patients when they are hospitalized (20, 23–25, 29, 30). However, it is difficult to identify an appropriate nonfracture comparison group since the demographic and health characteristics of hip fracture patients differ from those of many other groups of older persons.

The objective of this study was to estimate the change in physical function attributable to hip fracture. A cohort of hip fracture patients was followed prospectively from the point of fracture and was compared with a group of community-dwelling aged from the Established Populations for Epidemiologic Studies of the Elderly (EPESE) (31) matched by age, sex, and functional status. Changes in disability, defined as the inability to perform three ADL either independently or with assistance (human or equipment), were evaluated. Two ADL, walking across a room and transferring from bed to chair, require lower-extremity mobility and are likely affected by hip fracture; the third activity of daily living, grooming oneself, is an upper body task that should not be substantially affected by hip fracture. In addition, because baseline functional limitations are strongly associated with subsequent functional decline (32) as well as excess mortality following hip fracture (33), changes in these ADL after hip fracture were compared by level of preexisting comorbidity, functional limitations, and age.

MATERIALS AND METHODS

Study sample

The study sample comprised cohorts of elderly hip fracture patients in the Baltimore Hip Studies (BHS) (25) and persons from EPESE (31). Hip fracture was identified by hospitalization based on International Classification of Diseases, Ninth Revision, code 820. This hip fracture was the first for 91.9 percent of the respondents; thus, the 7.5 percent of EPESE respondents with a history of hip fracture at baseline were not excluded.

Hip fracture patients. These subjects participated in a study of health outcomes among patients aged 65 years or older who were admitted consecutively to one of eight hospitals in the Baltimore, Maryland, area during 1990–1991. Patients were excluded if they presented with pathologic fractures or resided in a nursing home, hospital, or extended-care facility. Of the 804 patients, 674 enrolled in a 2-year follow-up protocol. Additional information about construction of the sample can be found elsewhere (25). Data were collected through chart review and questionnaires administered in face-to-face interviews with patients (or a proxy if necessary) during the initial hospitalization. Face-to-face follow-up interviews were conducted with patients or proxies at 2, 6, 12, 18, and 24 months after hospitalization for hip fracture.

Comparison group. This group was derived from EPESE, a prospective study of risk factors associated with chronic disease, loss of functioning, and mortality among community-dwelling adults aged 65 years or older conducted at four sites in the United States: Massachusetts, Iowa, Connecticut, and North Carolina. Prospective data were available from three sites; therefore, our cohort was drawn from samples in Massachusetts (n = 3,421), Iowa (n = 3,492), and Connecticut (n = 2,539). A more complete description of the EPESE study can be found elsewhere (31, 32). Data were collected annually from 1982 through 1984. Face-to-face interviews were conducted with respondents or proxies (when necessary) at baseline, and telephone interviews were conducted during 12-month and 24-month follow-up. Previous evaluations of concordance between telephone and face-to-face reports of function have reported no notable differences in responses (34, 35).

Measures

Functional status was measured by self-reported ability to perform ADL. Three ADL questions were selected because they were worded similarly in the two studies: 1) walking indoors (BHS: “walk 10 feet (3 m) or across a room”; EPESE: “walking across a room”), 2) transferring from bed to chair (BHS: “get in and out of bed”; EPESE: “get from a bed to a chair”), and 3) grooming (BHS: “groom yourself (that is, brush hair and teeth); EPESE: “personal grooming such as brushing hair and teeth, or washing face”). In previous studies (27, 36), walking indoors and transferring have been associated with decline in lower-extremity functioning.

The ADL questions and response options differed slightly between the studies. In BHS, respondents were asked whether they had received help performing each activity of daily living during the past week. Baseline functioning referred to the week before the hip fracture. Response options were as follows: received no help, used help from equipment or a person, or unable to perform activity. In EPESE, respondents were asked whether there had been any time in the past 12 months when they needed help from a person or equipment to perform the activity. Response options were as follows: does not need help, gets help, or is unable to perform activity. To resolve differences, responses were recoded to “unable to perform or performs activity with assistance” versus other. In this paper, the percentage of those “unable to perform” at a specific time point is henceforth referred to as the disability rate.

Covariables available for both groups included age, sex, and five comorbid health conditions (diabetes, hypertension, cancer, stroke, and heart disease).

Merging the cohorts

The BHS cohort was older than the EPESE group and evidenced more limitations regarding ADL tasks. To minimize baseline differences between these groups, each of the three EPESE cohorts was frequency matched to the BHS
cohort on sex, 5-year age group, and ability to walk indoors at baseline. Ability to walk indoors was selected for matching because of its prime importance in recovery from hip fracture and its strong association with other lower-extremity tasks of daily living. The matching procedure is described in detail elsewhere (37).

**Analyses**

For each activity of daily living, the proportion of respondents in the hip fracture sample disabled at baseline, 12 months, and 24 months was compared with the corresponding proportion for each of the three matched EPESE samples. Because the data are longitudinal, these comparisons were not statistically independent. Thus, appropriate standard errors were derived by fitting generalized estimating equation models (38) to account for intrasubject correlation across the follow-up period. The dependent variable was disability (yes or no); the independent variables included indicator variables for group (BHS or EPESE), time (baseline, 12 months, 24 months), and group-by-time interactions. A log-link function, an unstructured covariance matrix, and a binomial error distribution were specified for the generalized estimating equation models. Model predictions were transformed to probabilities of disability through exponentiation.

To evaluate whether baseline comorbidities and functional status modified associations between having a hip fracture and ADL outcomes, three additional stratified analyses were conducted: one stratified by whether the respondent had one or more of three diseases at baseline (heart disease, cancer, or stroke) or was free of these diseases, a second stratified by whether the respondent was able or unable to walk across the room at baseline, and a third stratified by age (less than age 85 years vs. 85 years or older).

Attributable disability rates were computed as the change in disability rate from baseline to 24 months for the BHS cohort minus the change in disability rate from baseline to 24 months for the EPESE cohort. EPESE values were determined from the average of the disability rates over the three sites.

**RESULTS**

Of the 674 patients in the BHS cohort, 594 were matched with subjects from each of the three EPESE sites. Table 1 presents the characteristics of the 594 hip fracture patients and the matched respondents from EPESE. For the matched samples, the distributions of demographic, ADL, and comorbidity characteristics were similar. The average age of BHS patients was 80.5 years (standard deviation, 7.3), 75 percent were female, 93 percent were White, and 26 percent did not walk independently prior to fracture. The proportions of

| TABLE 1. Comparison (%) of matched hip fracture cohort and Established Populations for Epidemiologic Studies of the Elderly cohorts, United States |
|---|---|---|---|
| | Hip fracture cohort (n = 594) | EPESE cohorts |  |
| | | East Boston, Massachusetts (n = 594) | Iowa (n = 594) | New Haven, Connecticut (n = 594) |
| Age (years) | | | | |
| 65–69 | 8.4 | 8.4 | 8.4 | 8.4 |
| 70–74 | 12.6 | 12.6 | 12.6 | 12.6 |
| 75–79 | 23.4 | 23.4 | 23.4 | 23.4 |
| 80–84 | 23.4 | 23.4 | 23.4 | 23.4 |
| ≥85 | 32.2 | 32.2 | 32.2 | 32.2 |
| Sex: female | 75.4 | 75.4 | 75.4 | 75.4 |
| Race: White | 92.6 | 96.1 | 95.5 | 92.8 |
| ADL* dependence | | | | |
| Transferring | 13.0 | 13.8 | 13.3 | 12.0 |
| Walking | 26.1 | 26.1 | 26.1 | 26.1 |
| Grooming | 7.9 | 7.7 | 6.1 | 5.9 |
| Comorbidity | | | | |
| Diabetes | 11.3 | 16.0 | 9.8 | 12.1 |
| Hypertension | 44.4 | 43.2 | 45.3 | 45.0 |
| Cancer | 14.1 | 12.8 | 15.8 | 14.0 |
| Stroke | 10.6 | 5.4 | 8.1 | 7.6 |
| Heart disease | 11.8 | 12.2 | 11.0 | 13.0 |

* EPESE, Established Populations for Epidemiologic Studies of the Elderly; ADL, activities of daily living.
BHS patients and EPESE respondents reporting a prior hip fracture were 8.1 percent and 7.5 percent, respectively. The proportion of BHS patients with comorbid diseases ranged from 10.6 percent for a history of stroke to 44.4 percent for hypertension.

**ADL changes in hip fracture and comparison groups**

The proportions of respondents who were dependent regarding walking, transferring, and grooming at baseline, 12 months, and 24 months are shown in figures 1, 2, and 3 and in table 2. Because of matching, a similar proportion of respondents in the hip fracture and EPESE groups were dependent for these ADL at baseline. For tasks requiring the lower extremities, 26.1 percent of each group was dependent regarding walking and 12–14 percent of each group was dependent for transferring. However, 12 and 24 months later, the BHS group was considerably more dependent than the EPESE groups. About 50 percent of BHS patients were dependent for walking at 12 and 24 months, whereas only...
21–22 percent of EPESE respondents were dependent for this function at 12 months and 25–29 percent were dependent at 24 months. Likewise, 38–39 percent of the BHS group were disabled in transferring at 12 and 24 months as opposed to 10–13 percent of EPESE respondents at 12 months and 14–18 percent at 24 months. Similar results were observed with regard to grooming. At baseline, the BHS and EPESE groups were similar: 8 percent versus 6–8 percent reported disability. However, at 12 months, 17 percent of the BHS group reported disability in grooming compared with 7–11 percent of the EPESE groups. At 24 months, 19 percent of the BHS cohort and 10–15 percent of the EPESE groups were disabled.

Excess disability attributable to hip fracture

Attributable disability rates (excess number disabled per 100 hip fractures) are shown in Table 3. For every 100 hip fracture cases, 26 more were walking disabled, 22 more were transferring disabled, and six more were grooming disabled than would be expected after 2 years of aging. Excess disability among BHS patients was persistent in subgroups stratified by age, the presence of baseline comorbid conditions, and walking limitations. Although there was a tendency for larger excesses in attributable disability among subgroups that were older, sicker, and had walking limitations, hip fracture also had a substantial impact on disability.

Excess disability attributable to hip fracture

<table>
<thead>
<tr>
<th>ADL† dependence</th>
<th>Time period</th>
<th>Hip fracture cohort</th>
<th>EPESE‡ cohorts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>East Boston, Massachusetts</td>
<td>Iowa</td>
</tr>
<tr>
<td>Walking 10 feet§</td>
<td>Baseline</td>
<td>0.261 (0.018)</td>
<td>0.261 (0.018)</td>
</tr>
<tr>
<td></td>
<td>12 months</td>
<td>0.544 (0.024)</td>
<td>0.219 (0.018)***</td>
</tr>
<tr>
<td></td>
<td>24 months</td>
<td>0.528 (0.025)</td>
<td>0.259 (0.019)***</td>
</tr>
<tr>
<td>Transferring in/out of bed</td>
<td>Baseline</td>
<td>0.131 (0.014)</td>
<td>0.138 (0.014)</td>
</tr>
<tr>
<td></td>
<td>12 months</td>
<td>0.379 (0.024)</td>
<td>0.131 (0.015)***</td>
</tr>
<tr>
<td></td>
<td>24 months</td>
<td>0.388 (0.026)</td>
<td>0.176 (0.017)***</td>
</tr>
<tr>
<td>Grooming</td>
<td>Baseline</td>
<td>0.079 (0.011)</td>
<td>0.077 (0.011)</td>
</tr>
<tr>
<td></td>
<td>12 months</td>
<td>0.174 (0.018)</td>
<td>0.113 (0.014)***</td>
</tr>
<tr>
<td></td>
<td>24 months</td>
<td>0.183 (0.019)</td>
<td>0.140 (0.015)*</td>
</tr>
</tbody>
</table>

* p < 0.10 vs. hip fracture group; ** p < 0.01 vs. hip fracture group; *** p < 0.001 vs. hip fracture group.
† Disabled refers to receipt of assistance from equipment or another person to perform the task or an inability to perform the task.
‡ ADL, activities of daily living; EPESE, Established Populations for Epidemiologic Studies of the Elderly.
§ 10 feet = 3 m.
in subgroups that were younger, healthier, and able to walk independently.

**DISCUSSION**

Results of this study demonstrated that hip fracture patients had more disability over a 2-year period regarding three ADL (walking 10 feet (3 m) or across a room, transferring from bed to chair, and grooming) than a comparison group of older persons matched on age, sex, and walking ability. The proportion of hip fracture patients who were disabled at 12 months postfracture ranged from 17 percent for grooming to 54 percent for walking, which is consistent with other prospective studies of hip fracture patients (6, 20–25). However, these disability rates from prior studies overestimated the impact of the fracture somewhat since they did not account for losses that would have occurred had there not been a fracture. In the present study, the levels of disability attributable to the hip fracture were identified. Not surprisingly, hip fracture takes its greatest toll on lower-body function. We estimate that about one quarter of hip fractures in the elderly will result in permanent lower-body disability. Furthermore, among respondents who had ADL limitations at baseline, hip fracture increased the risk of functional decline over the follow-up period.

Together, these studies provide evidence that elderly persons who fracture a hip decline in both lower-extremity functioning and upper-extremity functioning over follow-up periods ranging from 6 weeks to 6 years. In the present study, most of the decline in walking and transferring ability occurred during the first 12 months. As expected, the impact of fracture on grooming was much smaller than on lower-extremity tasks. While the observed small excess loss may have been due to measurement differences between the cohorts or bias not accounted for by the analytic approach, it may also be a convalescent phenomenon associated with depressed mood, reduced ability to be mobile, and general reduction in activity (25).

The characteristics of our sample were similar to those in the study samples cited above (26–28), even though our hip fracture patients were identified when they were hospitalized for fracture and our comparison subjects were community-dwelling elderly persons matched to hip fracture patients on sex, age, and functional status. In our sample, the prevalence of baseline disability in transferring and walking was similar to that in the Marottoli et al. study (26). The hip fracture

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**TABLE 3. Excess disability attributable to hip fracture (per 100 patients) by age, comorbidity, and walking status, *,**†
United States, 1990–1991

<table>
<thead>
<tr>
<th>Walking 10 feet‡</th>
<th>65–84</th>
<th>≥85</th>
<th>0</th>
<th>≥1</th>
<th>Independent</th>
<th>Dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.3</td>
<td>23.0</td>
<td>33.5</td>
<td>25.1</td>
<td>29.3</td>
<td>24.8</td>
<td>27.9</td>
</tr>
<tr>
<td>Transferring in/out of bed</td>
<td>22.2</td>
<td>22.3</td>
<td>22.1</td>
<td>18.0</td>
<td>33.3</td>
<td>9.0</td>
</tr>
<tr>
<td>Grooming</td>
<td>6.0</td>
<td>3.7</td>
<td>10.7</td>
<td>4.6</td>
<td>9.8</td>
<td>3.7</td>
</tr>
</tbody>
</table>

* Disability refers to receipt of assistance from equipment or another person to perform the task or an inability to perform the task.
† Excess disability attributable to hip fracture refers to the excess number of cases of disability per 100 persons attributable to the hip fracture.
‡ 10 feet = 3 m.
patients also had similar mortality rates: 16 percent of our sample died over a 1-year period; about 20 percent died within the first year postfracture in the other studies (26, 27). The three EPESE cohorts in the present study were analyzed separately rather than merged into a single comparison group because they represented different groups in the population. The consistent results observed provide a reliable base for comparison and underscore the fact that hip fracture patients experience more functional decline over a 2-year period than sex-, age-, and function-matched peers.

The current study has several methodological strengths compared with previous studies. First, inclusion of a comparison group of elderly persons who had not fractured a hip enabled us to evaluate functional decline due to hip fracture versus that due to aging. Second, the design permitted measurement of functional status closer to the time of the fracture than in previous studies using comparison groups (26–28). Third, the repeated-measure analysis provided estimates of changes in functional status over the 2-year study period that accounted for correlations in persons’ functional status over time. Previous studies assessed functional status only once postfracture (26–28). Fourth, subjects in the EPESE and BHS cohorts were followed at the same intervals and for the same amount of time. By contrast, previous analyses of EPESE participants used a 1-year follow-up period for controls and a 6-month follow-up for hip fracture patients (26), and the analyses of the Longitudinal Study on Aging were restricted to a subset of respondents who participated in the 1990 follow-up interview (27). This study had a larger sample of hip fracture patients than previous ones (26–28). Furthermore, in contrast to previous studies, the groups in the present study were frequency matched on selected confounders, which increased the statistical power to detect and isolate an effect of hip fracture on functional decline.

This study had limitations as well. Differential loss to follow-up and use of proxies may have introduced bias in attributable disability estimates. There were more deaths in the hip fracture (16.1 percent) than in the EPESE (8.7 percent) cohorts over a year. Although use of generalized estimating equations enables subjects’ outcomes to contribute to the results while they are alive, those who died probably would have had the worst outcomes, thus producing an underestimate or a conservative view of the true attributable disability. Losses for other reasons were smaller in the hip fracture (1 percent) than in the EPESE (12.1 percent) cohorts. To the extent that those lost were more disabled than those retained, it is possible that the observed attributable disability overestimated the actual attributable disability. The differential use of proxies to obtain information from hip fracture patients and EPESE controls introduced another potential source of bias. Similar proportions of participants in the BHS (15.7 percent) and EPESE (15.2 percent) cohorts had proxy responses during follow-up; however, at baseline, 28 percent of the BHS information came from proxies compared with 17.2 percent in EPESE. Because proxies tend to overreport disability (39, 40), the baseline difference may produce more false positives in BHS than EPESE, thereby reducing the number of hip fracture patients for whom new disability can be reported and resulting in an underestimate or conservative estimate of the actual attributable disability. Whether underestimates stemming from differential survival or use of proxies compensate for possible overestimates attributable to losses for other reasons cannot be ascertained accurately; however, overall, the net bias stemming from differential survival or use of proxies is likely to be small.

Different reference frames regarding measures and period of cohort acquisition also may have affected attributable disability estimates. Because estimates of baseline ADL functioning used different intervals (1 week in BHS vs. 12 months in EPESE), the prevalence of disability in EPESE could reflect episodes that occurred and resolved during the year preceding the interview, thereby attenuating the disability estimate. In addition, BHS and EPESE data were collected approximately 8 years apart. Although we are aware of no notable changes in the management of hip fracture or disability during this period, findings suggesting that more recent cohorts of older persons are less disabled (41) raise the possibility that changes in BHS patients are smaller than those in EPESE participants. Although we do not think that the effect would be great since we adjusted for comorbidity and functional differences between the groups, any effect would also favor an underestimate of disability attributable to hip fracture.

Because of the limited number of measures obtained in a similar manner in BHS and EPESE, we assessed change in only three ADL and controlled for a limited number of confounding variables. Nonetheless, these ADL have been studied extensively as important outcomes (21–27). Finally, although results of this study are generalizable mainly to older White women, they provide important information for health care providers because this group has the highest risk of hip fracture (1).

We used a novel method to construct a comparison group of community-dwelling older adults to evaluate whether hip fracture patients experienced more functional disability than would be expected in a similar group who did not fracture. Although we could not evaluate whether those who fracture decline at a different rate before fracture and would consequently have a different level of function a year or two later than the nonfracture comparison group, results do indicate that hip fracture patients have higher levels of disability than expected over a 2-year follow-up period regarding three ADL that reflect both lower-extremity and upper-extremity functioning. The excess disability in these functions attributable to hip fracture was substantial and was not restricted to special subgroups (table 3). Comparing hip fracture patients with matched groups in the general population identifies a level of improvement to strive for when intervening to maximize functional recovery after hip fracture. These results provide an estimate of the amount of disability attributable to hip fracture. Results add to the evidence that hip fracture produces a substantial decline in functioning, and they support the need for interventions to prevent fracture and to improve rehabilitation and treatment for older persons who fracture a hip.
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REFERENCES