Validation on Efficiency Pattern Analysis for Geriatric Hip Fractures Rehabilitation

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ABSTRACT

Seven hundred and sixty-three elderly patients with hip fractures were recruited in the study. The Functional Independence Measure (FIM) was used to measure their functional status on admission and upon discharge, and their difference was defined as functional change. An Efficiency Pattern Analysis Matrix was formed with Efficiency Pattern Analysis (EPA) and was used for in-depth matrix characteristics analysis. A validation study was also conducted with another group of patients (n = 455) so that the stability of EPA across time was affirmed. We found that 23.3% of patients are in “higher efficiency” group [higher motor-FIM gains with shorter length of stay (LOS)], 8.5% in “higher gain and longer stay” group (higher motor-FIM gains with longer LOS), 32.5% in “average efficiency” group, 12% in “lower gain and shorter stay” (lower motor-FIM gain and shorter LOS), and 23.7% of patients in “lower efficiency” group (intermediate motor-FIM gains with longer LOS). The demographic and functional characteristics among these groups would be also analysed.

Introduction

Hip fracture is a leading cause of disability and morbidity in the elderly. This often results in significant functional impairment and prolonged institutionalisation. Inpatient hospital rehabilitation was shown to be effective in improving physical function after hip fractures. However, some other studies reported that most patients with hip fractures would not regain pre-morbid functional levels in activities of daily living (ADL). It appears that some of these patients may require more intensive rehabilitation training and care to help them restore their pre-morbid functional level, whereas others do not benefit from it.

Efficiency Pattern Analysis (EPA) is a medical rehabilitation tool to form the Efficiency Pattern Analysis Matrix (EPAM) (Figure 1). EPA correlates the patients’ functional gain by the measurement of Functional Independence Measure (FIM) and resource utilization, which is approximated by length of stay (LOS) as shown in Figure 2. EPA can also form a classification of efficiency matrix and be used in analysing the effectiveness of rehabilitation.
EPA in orthopaedic rehabilitation helps to monitor case management and cost containment. The LOS of patients in the hospital is a major determinant of resource used. Functional recovery is an important rehabilitation outcome indicator.

**Methods**

Geriatric patients, older than 65 years, with hip fractures, transferred to a rehabilitation hospital on their 1\textsuperscript{st} admission after surgical operations in an acute hospital were included in the study. Medical officers, nurses, occupational therapists, and physiotherapists would then provide a multidisciplinary rehabilitation program. The exclusion criteria were incompleteness of the whole rehabilitation program, transfer out from rehabilitation to an acute care hospital without return within 30 days, transfer to another rehabilitation setting, post-operative delirium, pre-existing history of mental retardation or neurological disorders, in-hospital death and major trauma history, or the present hip fracture being caused by multiple trauma.

The patients’ functional status would be assessed by FIM within 48 hours of admission (i.e. admission data) and on the day before discharge (i.e. discharge data). Patients’ functional change/gain was defined as the difference between the admission FIM and discharge FIM. Their LOS in the rehabilitation hospital was recorded. All patients received a rehabilitation program, which included reconditioning training and ADL training.

FIM is widely used by occupational therapists as an assessment tool for clinical decision making and outcome measurement.\textsuperscript{5,7,8} The FIM is well studied and validated.\textsuperscript{5,7,10} The scale can reflect the degree of functional disability after hip fractures and predict the functional outcome from the admission score.\textsuperscript{12–17} It has been used extensively in assessing patients with hip fractures and was verified to be an important clinical tool.\textsuperscript{3,4,9,14,18} The FIM is divided into two uni-dimensional scales: 13-item motor-FIM and five-item cognitive-FIM. These subscales distinguish physical and cognitive disabilities. The motor-FIM consists of four motor function domains: self-care (feeding, grooming, bathing, dressing upper and lower garments, and toileting), sphincter control (bladder and bowel), transfers (bed/chair/wheelchair transfer, toilet transfer, and tub/shower transfer), and locomotion (walking/wheelchair and climbing stairs). The maximum score of motor-FIM is 91. The cognitive-FIM consists of two cognitive function domains: communication (comprehension and expression) and cognition (social interaction, problem solving, and memory). The maximum score of cognitive-FIM is 35.

The FIM is scored by the trained occupational therapist, and the data are used to determine the potential benefit of treatment in the patient. Each score of FIM means different level of assistance required, as shown in the appendix. A score of “1” means “total assistance”, in which the person puts forth less than 25% of the effort necessary to do a task. A score of “2” means “maximal assistance”, in which the person puts forth less than 50% but at least 25% of the effort necessary to do a task. If someone gets a score of “1” or “2” on the FIM, he/she is classified as having “complete dependence” because the person puts forth less than half the energy, requires maximal or total assistance, or even worse—the activity is not performed at all. A score of “3” on the FIM means “moderate assistance”, in which the person puts forth 50% and 75% of the effort necessary to do a task and requires no more than helping or touching. A score of “4” means “minimal contact assistance”, in which the person puts forth 75% or more of the effort necessary to do a task and requires no more help than touching. A score of “5” means “supervision or setup”, in which the person only needs someone to standby and cue or coax him/her (without physical contact) so that he/she can do a task. A score of “5” can also be obtained if a helper is needed to set up items or assistive devices for the person. If someone gets a score of “3”, “4”, or “5” on the FIM, he/she is classified as having “modified dependence” because the person can at least put forth half or more of the energy to complete the task. A score of “6” on the FIM means “modified independence”, in which no helper is needed and the person needs an assistive device. A score of “6” can also be obtained when no help is needed but the person takes considerable time to do a task or may complete the task in an unsafe manner. A score of “7” means “total independence”, in which no helper is needed and the person performs the task safely, within a reasonable amount of time and without assistive devices, aids, or changes. If someone gets a score of “6” or “7” on the FIM, he/she is classified as being “independent” because another person is not needed to complete the activity.

Data on FIM, LOS, and other demographic information were collected. For FIM and LOS, cut-off points were set at the upper (75\textsuperscript{th} percentile) and lower (25\textsuperscript{th} percentile) boundaries of the inter-quartile range. The 25\textsuperscript{th} and 75\textsuperscript{th} percentile cut-off points were selected to allow for adequate numbers of patient in each

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**Figure 1.** The Efficiency Pattern Analysis Matrix model. LOS – length of stay; FIM – Functional Independence Measure; FRG – Function Related Group.
Table 1
Motor-Functional Independence Measure gain for 763 patients from 2001 to 2004

<table>
<thead>
<tr>
<th>Motor-FIM change</th>
<th>Motor-FIM gain (for 763 patients from 2001 to 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher motor-FIM gain categories</td>
<td>≥20</td>
</tr>
<tr>
<td>Intermediate motor-FIM gain categories (i.e. 26th–75th percentile)</td>
<td>3–19</td>
</tr>
<tr>
<td>Lower motor-FIM gain categories (i.e. 25th percentile or below)</td>
<td>≤2</td>
</tr>
</tbody>
</table>

Table 2
Rehabilitation length of stay for 763 patients from 2001 to 2004

<table>
<thead>
<tr>
<th>Rehabilitation LOS (for 763 patients from 2001 to 2004)</th>
<th>LOS (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shorter rehabilitation LOS (i.e. 25th percentile or below)</td>
<td>≤16</td>
</tr>
<tr>
<td>Intermediate rehabilitation LOS (i.e. 26th–75th percentile)</td>
<td>17–28</td>
</tr>
<tr>
<td>Longer rehabilitation LOS (i.e. 76th percentile or above)</td>
<td>≥29</td>
</tr>
</tbody>
</table>

LOS – length of stay.
efficiency group for comparative analyses. For the analysis of EPA, in order to get a specific and unique analysis on motor performance of subjects, we focused on the “motor-function” construct of patients with hip fractures, and therefore, we categorize them by the score on “motor-FIM” gain.

Table 3
Motor-FIM gain categories (for 455 patients from 2004 to 2005) | Motor-FIM change
---|---
Higher motor-FIM gain categories (i.e. 76th percentile or above) | ≥20
Intermediate motor-FIM gain categories (i.e. 26th–75th percentile) | 4–19
Lower motor-FIM gain categories (i.e. 25th percentile or below) | ≤3

Table 4
Rehabilitation length of stay categories (for 455 patients from 2004 to 2005) | LOS (d)
---|---
Shorter rehabilitation LOS (i.e. 25th percentile or below) | ≤16
Intermediate rehabilitation LOS (i.e. 26th–75th percentile) | 17–28
Longer rehabilitation LOS (i.e. 76th percentile or above) | ≥29

LOS – length of stay.

With cross-tabbing analysis and exploration of data set, the motor-FIM gain dimension was categorized as “higher” (76th percentile or above), “intermediate” (26th–75th percentile), and “lower” (25th percentile or below). LOS categories were “shorter” (25th percentile or below), “intermediate” (26th–75th percentile), and “longer” (75th percentile or above). The 95% confidence intervals for each estimate were used to compare differences across efficiency groups. The statistical significant difference is set at \( p \leq 0.05 \).

Results

Motor-FIM gain categories and LOS categories of the 763 patients are summarised in Tables 1 and 2, respectively. Further validation of the EPA was conducted from another group of geriatric hip fracture patients (\( n = 455 \)) who were recruited from 2004 to 2005. Their motor-FIM gain and LOS categories are summarised in Tables 3 and 4, respectively. Results were very similar among data of these 2 years, and there was no statistical significant difference between these two data sets (\( p > 0.05 \)).

EPAM consists of nine cells defined by quartile values based on cut-off points from the motor-FIM gain and LOS distributions. The primary-EPAM with 763 patients is formulated in Figure 3, and the validate-EPAM of 455 subjects is shown respectively in Figure 4.

Figure 3. The Primary Efficiency Pattern Analysis Matrix model for 763 geriatric hip fracture patients. LOS – length of stay.

Figure 4. The Validate Efficiency Pattern Analysis Matrix model for 455 geriatric hip fracture patients. LOS – length of stay.
EPAM provided a stable platform in measurements over time. There were 23.3% of patients in Group I, the “higher efficiency” group (motor-FIM gains are higher with shorter LOS); 8.5% in Group II, the “higher gain and longer stay” group (higher motor-FIM gains with longer LOS); 32.5% in Group III, the “average efficiency” group; 12% in Group IV, the “lower gain and shorter stay” group (lower motor-FIM gain and shorter LOS); and the remaining 23.7% of patients in Group V, the “lower efficiency” group (intermediate motor-FIM gains with longer LOS), as shown in Figures 3 and 4. We also noted that the EPA provided a stable efficiency group classification in functional gain across time.

The demographic and functional characteristics of patients in each efficiency group also shared similar findings. To further disseminate pre-morbid characteristics of patients in different efficiency groups, the admission demographic characteristics data and their pre-morbid function characteristics are summarised in Figures 5 and 6 and Figures 7 and 8, respectively. EPAMs shared similar pattern of distribution among these different data sets.

**Discussion**

In efficiency Group IV, “lower gains and shorter stay”, as shown in Figures 7 and 8, more than half of patients were functional assisted or even dependent prior to admission. Nearly two-thirds of patients in this group were old-age home residents. Their LOS was less than 16 days. Their short LOS was due to their limited potential in functional gain, and their pre-morbid ADL had been taken care of by staff of the old-age home. Therefore, this group of patients could be discharged shortly after their orthopaedic problems were settled.

As shown in Figures 5 and 6, motor-FIM change and Motor-FIM change across time (also termed as motor-FIM change efficiency) were significantly lower in efficiency Group V—the “lower efficiency” group. This group of patients was characterised as dependent in “self-care” domains in FIM measures. In the “lower efficiency” group, patients showed lower rehabilitation potential but longer LOS when compared with other groups of patients. This group of patients showed only about 2.5 motor-FIM change despite an LOS for about 35 days. Treatment effectiveness of this group of patients is doubtful. As shown in Figures 7 and 8, this group of patients was assistance required in their pre-morbid function or even more prone to dependent. These patients required assistance in ADL prior to their hip fractures and their pre-morbid motor function was poor. Poor prognosis could be expected. This group of patients probably required more training in preventive measures like fall prevention and sore prevention than conventional rehabilitation training. Moreover, availability of caregivers on discharge and feasibility of proper institutional placement could be advocated in an earlier phase of pre-discharge planning.

**Figure 5.** The Primary Efficiency Pattern Analysis Matrix model for 763 geriatric hip fracture patients (with admission data). LOS = length of stay; FIM = Functional Independence Measure; Ad M FIM = Admission Motor FIM.

**Figure 6.** The Validate Efficiency Pattern Analysis Matrix model for 455 geriatric hip fracture patients (with admission data). LOS = length of stay; FIM = Functional Independence Measure.
Efficiency matrix Group I showed significant change in motor-FIM when compared with the other functional classes \((p < 0.05)\) as shown in Figures 5 and 6. This “higher efficiency” group showed significant motor-FIM change and required short rehabilitation LOS. Patients in this group only required LOS of less than 16 days in average to have motor-FIM gain of 20 scores or above. In practice, rehabilitation can be geared to this group of patients with a better cost-effective rehabilitation program. Moreover, as shown in Figures 7 and 8, more than 90% of patients in this group were independent in pre-morbid function. Therefore, pre-morbid competence in ADL could be a screening factor for patients who have better rehabilitation potential. They probably required more intensive training on instrumental ADL, a highly functional demand ADL (like shopping, meal preparation, and household chores management), energy conservation techniques, and joint protection precautions to assess their earlier reintegration to community rather than basic ADL training.

In efficiency matrix Group II, the “higher gains and longer stay” group, patients got the greatest improvement in motor-FIM change of about 28 scores. When compared with efficiency matrix Group I, the “higher efficiency” group, statistically significant difference noted in motor-FIM change with mean difference was 3.25 \((p < 0.05)\). In other words, the “higher gains and longer stay” group showed the greatest improvement in function when compared with other groups. As shown in Figures 7 and 8, nearly 85% of patients were independent in pre-morbid function, and majority of them were pre-morbid home residents. Therefore, this group of patients deserved longer LOS so as to ensure their function capable of being discharged to community.

For efficiency matrix Group III, it covers an LOS with 26th–75th percentile and FIM gains with 26th–75th percentile. This “average efficiency” group had a mean admission motor-FIM score around 55 and produce motor-FIM gain about 12 as shown in Figures 5 and 6. They showed less improvement when compared with efficiency matrix Group I (the “higher efficiency” group) and Group II (the “high gains and shorter stay” group), but the patients’ functional performance remained stable when compared with efficiency matrix Groups IV and V. As shown in Figures 7 and 8, majority of patients in this group were functional independent prior to admission but their functional gain was not as high as the “higher efficiency” and “high gains and shorter stay” groups. Therefore in this stage, efficiency matrix Group III could be considered as a “marginal” improvement group. Further study on the characteristics of this group of “average” patients would be required if their improvement in motor function was different or other factors like mental function, education level, and socio-economical reasons contributed.

**Figure 7.** The Primary Efficiency Pattern Analysis Matrix model for 763 geriatric hip fracture patients (with pre-morbid function). LOS – length of stay; ADL – activities of daily living; Indep – independent.

**Figure 8.** The Validate Efficiency Pattern Analysis Matrix model for 455 geriatric hip fracture patients (with pre-morbid function). LOS – length of stay; ADL – activities of daily living; Indep – independent.
In conclusion, EPA is a simple way to quantify the functional gain with the LOS. It can measure the efficiency of geriatric hip fracture rehabilitation program and its cost-effectiveness. Validation study confirmed that EPA is a stable and reliable tool across time.

Appendix. Assessment scale

<table>
<thead>
<tr>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No helper</td>
<td>(Timely, safely)</td>
</tr>
<tr>
<td>7 Complete independence</td>
<td>(Device)</td>
</tr>
<tr>
<td>6 Modified independence</td>
<td></td>
</tr>
<tr>
<td>Helper-modified dependence</td>
<td></td>
</tr>
<tr>
<td>5 Supervision</td>
<td>(Subject – 100%)</td>
</tr>
<tr>
<td>4 Minimal assistance</td>
<td>(Subject – 75% or more)</td>
</tr>
<tr>
<td>3 Moderate assistance</td>
<td>(Subject – 50% or more)</td>
</tr>
<tr>
<td>Helper-complete dependence</td>
<td></td>
</tr>
<tr>
<td>2 Maximal assistance</td>
<td>(Subject – 25% or more)</td>
</tr>
<tr>
<td>1 Total assistance or not testable</td>
<td>(Subject less than 25%)</td>
</tr>
</tbody>
</table>

References