

ORIGINAL ARTICLE

Item Difficulties of the FIM-Motor Subscale in Patients with Ischemic Stroke during Acute Care: An Ordinal Logistic Modeling Study

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Objective: The aim of the current study was to assess the item difficulties of the motor subscales of the Functional Independence Measure (FIM-motor) in patients with ischemic stroke during acute care. **Methods:** FIM scores were assessed for each patient on admission to, and discharge from, acute care. The relationship between individual FIM-motor items (target variables) and the total FIM-motor score (explanatory variable) was assessed by ordinal logistic modeling. The total FIM-motor scores that corresponded to a 50% probability of independence level 5 (supervision or setup) for each FIM-motor item were assessed. **Results:** A total of 250 patients (155 men, 95 women) were included in the analytical database. The median age was 74 (interquartile range [IQR], 66–81) years and the median length of hospital stay was 14 (IQR, 10–24) days. Ordinal logistic modeling was successfully performed for all 13 FIM-motor items. The total FIM-motor scores that corresponded to a 50% probability of independence level 5 for individual FIM-motor items were as follows: eating, 34.1; bowel management, 42.2; bladder management, 43.4; grooming, 51.0; toileting, 62.0; dressing the lower body, 64.5; transfer to bed/chair/wheelchair, 65.5; transfer to toilet, 65.9; bathing, 70.3; dressing the upper body, 73.6; locomotion, 74.2; transfer to tub/shower, 80.0; and stair climbing, 89.2. **Conclusions:** These results revealed that eating, grooming, and bowel and bladder management were relatively easy, whereas gait-related items such as locomotion and stair climbing were difficult. Items such as transfer to bed/chair/wheelchair and toileting had intermediate difficulty. These results should facilitate efficient rehabilitative treatments during acute care.

Key Words: assessment; infarct; outcome; prognosis; recovery

INTRODUCTION

Previous studies have indicated that the physical disabilities of patients with stroke follow similar patterns.^{1–3)} Advances in computer software and information technology since the 1990s have meant that studies using Rasch analysis were able to elucidate the patterns of physical disability evaluated using the Functional Independence Measure (FIM).^{4–11)} Typically, eating, grooming, and bowel and bladder manage-

ment are the more easily accomplished activities, whereas bathing, transfers to a tub/shower, and stair climbing are more challenging activities. Activities of intermediate difficulty are dressing, toileting, and transfers to a bed/chair/wheelchair.⁶⁾ Knowledge of such patterns of item difficulty contributes to efficient rehabilitative treatments by providing a benchmark of target activities for appropriate training during the recovery stage after stroke.³⁾

Rasch analysis has been successfully used to determine

Received: July 22, 2020, Accepted: September 15, 2020, Published online: September 29, 2020

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item difficulties of the FIM motor subscale (FIM-motor).^{4–11} However, the results are often indexed as numerical values termed “logits”. Although these values represent relative difficulties, the interpretation of estimated logits in the clinical setting is not easy because they cannot be simply converted to total FIM-motor scores. To overcome this drawback, we followed an alternative approach that employed ordinal logistic modeling, which allows the characterization of item difficulties in reference to total FIM-motor scores.¹² This approach also shows probabilistic distributions of the independence levels (FIM levels 1 to 7) of the 13 individual items in relation to the total FIM-motor scores.¹²

Recent studies have demonstrated the importance of early initiation of rehabilitative treatments for stroke patients during acute care.^{13,14} The population of stroke patients during acute care is heterogeneous in terms of the degree of stroke severity; some patients can walk and return home after several days of hospital stay, whereas others need assistance in activities of daily living (ADL) such as dressing, toileting, and gait. Naturally, the focus of rehabilitative treatments is also varied in response to the wide range of stroke severity. However, most existing studies on FIM item difficulties collected data from long-term rehabilitation facilities to which patients were transferred after acute care. No studies have systemically analyzed FIM-motor item difficulties during acute care. In the current study, to extend the knowledge of FIM-motor item difficulties to the acute care setting, we enrolled patients in an acute care hospital and assessed FIM-motor item difficulties by applying ordinal logistic modeling.

METHODS

Patients

We retrospectively enrolled patients with ischemic stroke who were admitted to the Stroke Care Unit (SCU) of Nishinomiya Kyoritsu Neurosurgical Hospital between April 2015 and March 2016. The diagnosis of ischemic stroke was made based on diffusion-weighted magnetic resonance imaging obtained using a 3.0-T scanner (Trio; Siemens AG, Erlangen, Germany).¹⁵ The study protocol was approved by the Hyogo College of Medicine Ethics Committee (No. 2454). Informed consent was obtained using the opt-out method.

During hospitalization, patients typically received conservative treatment such as medication in accordance with the guidelines of the Japanese Stroke Society.¹⁶ Patients also underwent physical therapy, occupational therapy, and speech therapy for up to 180 min/day (combined daily total).¹⁷ Under the Japanese medical insurance system, after inpatients with

stroke have received medical treatments for several weeks in an acute care hospital they are typically discharged home or transferred to a long-term rehabilitation facility.¹⁸

From medical records during hospitalization, we collected patient data including age, sex, modified Rankin Scale (mRS) score before stroke onset, National Institutes of Health Stroke Scale (NIHSS) score on admission, the day on which rehabilitative treatment was initiated (initial rehabilitation), length of hospital stay, and FIM scores.¹⁹ Criteria for inclusion in our analytical database were pre-hospitalization mRS \leq 1, undergoing rehabilitative treatment, and exhibiting no deterioration of symptoms (indexed by the NIHSS score) within 7 days after stroke onset.

FIM Measurements

FIM is one of the most frequently used scoring systems for assessing the ability to perform ADL during the rehabilitation of stroke patients.²⁰ The motor subscale of the FIM (FIM-motor) includes the following 13 items: eating, grooming, bathing, dressing the upper body, dressing the lower body, toileting, bladder management, bowel management, transfers to bed/chair/wheelchair, transfers to toilet, transfers to tub/shower, locomotion (walking or wheelchair propulsion), and stair climbing. FIM item scores are systemically graded on a seven-point scale (1, total assistance; 7, complete independence). The total FIM-motor score (range, 13–91) is often used as an index of the ability to perform ADL.^{1–3} In this study, FIM scores were sampled twice during hospitalization, once at initial rehabilitation (typically 0–2 days after admission) and once on discharge. These two datasets were merged into one analytical database. The scores were assessed by physical therapists in agreement with attending nursing staff.

Statistical Analysis

To determine associations between the total FIM-motor score (explanatory variable) and the independence levels of individual FIM-motor items (target variables), ordinal logistic modeling analysis was applied.²¹ The details of applying ordinal logistic modeling to FIM-motor data were reported in our previous study.¹² As in that study, the total FIM-motor score that corresponded to a 50% probability of independence level 5 (supervision or setup) for each item was evaluated and then used as an index for the item difficulty. All statistical analyses were performed using JMP software version 14.2.0 (SAS Institute Inc., Cary, NC, USA). A P value of less than 0.05 was considered statistically significant.

Table 1. Patient demographics (n = 250)

| Patient | | |
|-----------------|-------------|------------|
| Gender | Male/female | 155/95 |
| Age (years) | | 74 (66–81) |
| NIHSS score | Admission | 3 (1–6) |
| FIM-motor score | Admission | 60 (43–71) |
| | Discharge | 83 (68–88) |
| LOS (days) | | 14 (10–24) |

Data are shown as the median (interquartile range) or number of patients.

NIHSS, National Institutes of Health Stroke Scale; LOS, length of hospital stay.

RESULTS

Patient Characteristics

A total of 527 patients with ischemic stroke were admitted to the SCU of Nishinomiya Kyoritsu Neurosurgical Hospital during the study period. Of these, 425 underwent rehabilitative treatment. Patients with an NIHSS score of 0 and those with life-threatening severe stroke typically did not undergo rehabilitative treatment. Overall, we excluded 175 patients from our analytical database, either because they did not meet the pre-hospitalization mRS criteria (n = 154), had deterioration of symptoms within 7 days after stroke onset (n = 17), or had missing data (n = 4). As a result, information from 250 patients were entered into the final database.

Table 1 shows the patient characteristics from our analytical database. The median age was 74 years and there were more men than women (62%, n = 155/250). The median NIHSS score at initial rehabilitation was 3. The median length of hospital stay was 14 days.

Table 2 shows the parameter estimates obtained using ordinal logistic modeling analyses for all 13 FIM-motor items. For each individual FIM-motor item, the fit of ordinal logistic modeling was statistically significant, indicating that the results in the dataset could be validly interpreted as logistic probabilities. **Figure 1** shows the total FIM-motor scores that corresponded to a 50% probability of independence level 5 (supervision or setup) for each FIM-motor item (calculated using the parameters given in **Table 2**). The estimated total FIM-motor scores that corresponded to supervision or setup levels for eating, grooming, and bowel and bladder managements ranged from 30 to 55, indicating that these were relatively easy items. In contrast, the estimated values for dressing the upper body, locomotion, transfer to the tub/shower, and stair climbing exceeded a total FIM-motor score of 70, suggesting that these items were relatively difficult. The remaining five items (toileting, dressing the lower body, transfer to bed/chair/wheelchair, transfer to the toilet, and bathing) were estimated to be of intermediate difficulty.

Figure 2 shows logistic curves derived using the parameters given in **Table 2**. Ordinal logistic curves successfully outlined the probabilistic distribution of the independence

Table 2. Parameter estimates from logistic modeling

| Item | Coefficient | Intercept | | | | | | R ² |
|--------------|-------------|-----------|---------|---------|---------|---------|---------|----------------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | |
| Eating | -0.0997 | 2.0584 | 2.1147 | 2.3349 | 2.6356 | 3.4000 | 6.3167 | 0.3258 |
| Bowel | -0.1612 | 5.9320 | – | 6.2292 | 6.3860 | 6.8043 | 7.1854 | 0.5588 |
| Bladder | -0.1647 | 5.3092 | 5.8946 | 6.3252 | 6.5959 | 7.1520 | 7.5264 | 0.5306 |
| Grooming | -0.1335 | 3.8726 | 3.9890 | 4.8883 | 5.6212 | 6.8145 | 9.0335 | 0.3966 |
| Toileting | -0.2043 | 5.8695 | 6.5303 | 8.6258 | 10.2119 | 12.6750 | 13.2775 | 0.5257 |
| Dress low | -0.1774 | 7.2317 | 7.4807 | 8.8048 | 10.3059 | 11.4493 | 11.7328 | 0.4593 |
| Bed trans | -0.1962 | 4.1311 | 4.7944 | 6.0998 | 8.6675 | 12.8463 | 13.3564 | 0.5282 |
| Toilet trans | -0.2075 | 5.0527 | 5.3948 | 6.9132 | 9.5379 | 13.6710 | 14.2043 | 0.5474 |
| Bathing | -0.1271 | 5.9230 | 6.0949 | 6.8886 | 8.1785 | 8.9427 | 9.6414 | 0.3073 |
| Dress up | -0.1834 | 7.8353 | 7.9826 | 9.1875 | 12.7833 | 13.5041 | 13.7492 | 0.4630 |
| Locomotion | -0.1963 | 10.2675 | 10.3769 | 10.5292 | 11.1992 | 14.5659 | 15.3095 | 0.4578 |
| Tub trans | -0.1551 | 10.9737 | 11.0523 | 11.1509 | 11.5324 | 12.4155 | 13.0531 | 0.2993 |
| Stairs | -0.2638 | 22.2251 | – | 22.3293 | 22.5254 | 23.5183 | 24.0088 | 0.3521 |

All logistic modeling analyses were statistically significant (P < 0.001). The intercept numbers 1–6 are the independence levels for each motor item. Locomotion data include scores for walking or wheelchair propulsion. Bed trans, transfers to bed/chair/wheelchair; Dress low, dressing the lower body; Dress up, dressing the upper body; Toilet trans, transfers to toilet; Tub trans, transfers to the tub/shower; Stairs, stair climbing.

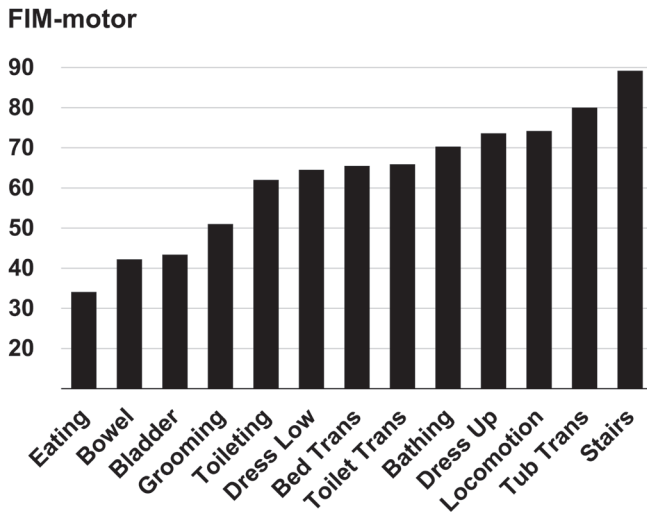


Fig. 1. FIM-motor scores that corresponded to a 50% probability of FIM independence level 5 (supervision or setup) for individual FIM-motor items. Bars were calculated using the parameter estimates shown in **Table 2**. Bed Trans, transfers to bed/chair/wheelchair; Dress Low, dressing the lower body; Dress Up, dressing the upper body; FIM-motor, the motor components of the Functional Independence Measure; Toilet Trans, transfers to the toilet; Tub Trans, transfers to the tub/shower; Stairs, stair climbing.

levels of FIM-motor items. Steeper logistic curves indicate better model fits, as indexed by the R^2 values (**Table 2**). Data for transfers to bed/chair/wheelchair showed steep, evenly distributed logistic curves across the entire range of the horizontal axis. This pattern indicated that independence levels (1–7) within this single FIM-motor item were proportionally associated with overall FIM-motor scores. Logistic curves for transfer to the tub/shower and stair climbing were strongly displaced to the right, close to the high end of the FIM-motor score, indicating that these were the most difficult FIM-motor items and had low variability. Data for eating showed a unique pattern with a wide range for independence level 6, suggesting that patients after stroke could easily reach modified independence for eating but that higher levels of independence were much more difficult to attain.

DISCUSSION

Subsequent to our previous study conducted in a convalescent rehabilitation ward,¹²⁾ in the current study, we applied ordinal logistic modeling to FIM data obtained from patients with ischemic stroke who were hospitalized in an

acute care hospital. The results indicated that FIM items such as eating, grooming, and bowel and bladder management were relatively easy, whereas items such as dressing the upper body, locomotion, transfer to the tub/shower, and stair climbing were relatively difficult; the remaining activities, i.e., toileting, dressing the lower body, transfer to bed/chair/wheelchair, transfer to the toilet, and bathing were of intermediate difficulty.

Going further than the analysis of item difficulties determined in previous studies using Rasch analysis,^{4–11)} in the current study we applied ordinal logistic modeling and revealed probabilistic distributions of independence levels (1–7) within a given single FIM-motor item. For example, for the transfer to bed/chair/wheelchair item, the independence level was almost proportional to the total FIM-motor score (**Fig. 2**). This observation suggests that assessing this single item may be efficient when a quick survey of disability as a whole is needed (e.g., during the first bedside round). In contrast, for eating, although patients after stroke could easily reach modified independence, complete independence was much more difficult to attain (**Fig. 2**). These results illustrate that analysis of FIM data using ordinal logistic modeling can be more informative than simple item difficulty indexed by logits indexed by Rasch analysis.^{4–11)}

These findings, obtained from patients in an acute care hospital, differed from those obtained from patients in a convalescent rehabilitation ward.¹²⁾ The major differences were the estimated item difficulties for dressing the lower body and locomotion (shown in **Figs. 1 and 2**). Although dressing the lower body was identified as one of the most difficult items among stroke patients in a convalescent rehabilitation ward, it was estimated as having intermediate difficulty among patients in an acute care hospital. This discrepancy could be attributed to different characteristics among the study subjects. In our previous study conducted in a long-term rehabilitation facility,¹²⁾ we limited inclusion to patients who needed a wheelchair for locomotion on admission. In contrast, the current study included many patients who could walk independently. The results for locomotion showed a relatively wide area for level 7 (**Fig. 2**), indicating that many subjects achieved independent gait. Moreover, the median NIHSS score on admission was 3 (**Table 1**), which implies that stroke symptoms were mild among the patients enrolled in the present study. For such patients, dressing the lower body was not a difficult FIM-motor item.

The current results show some features specific to the acute care setting. For dressing the upper body, the obtained logistic curves showed a wide area for level 4 (**Fig. 2**). Close

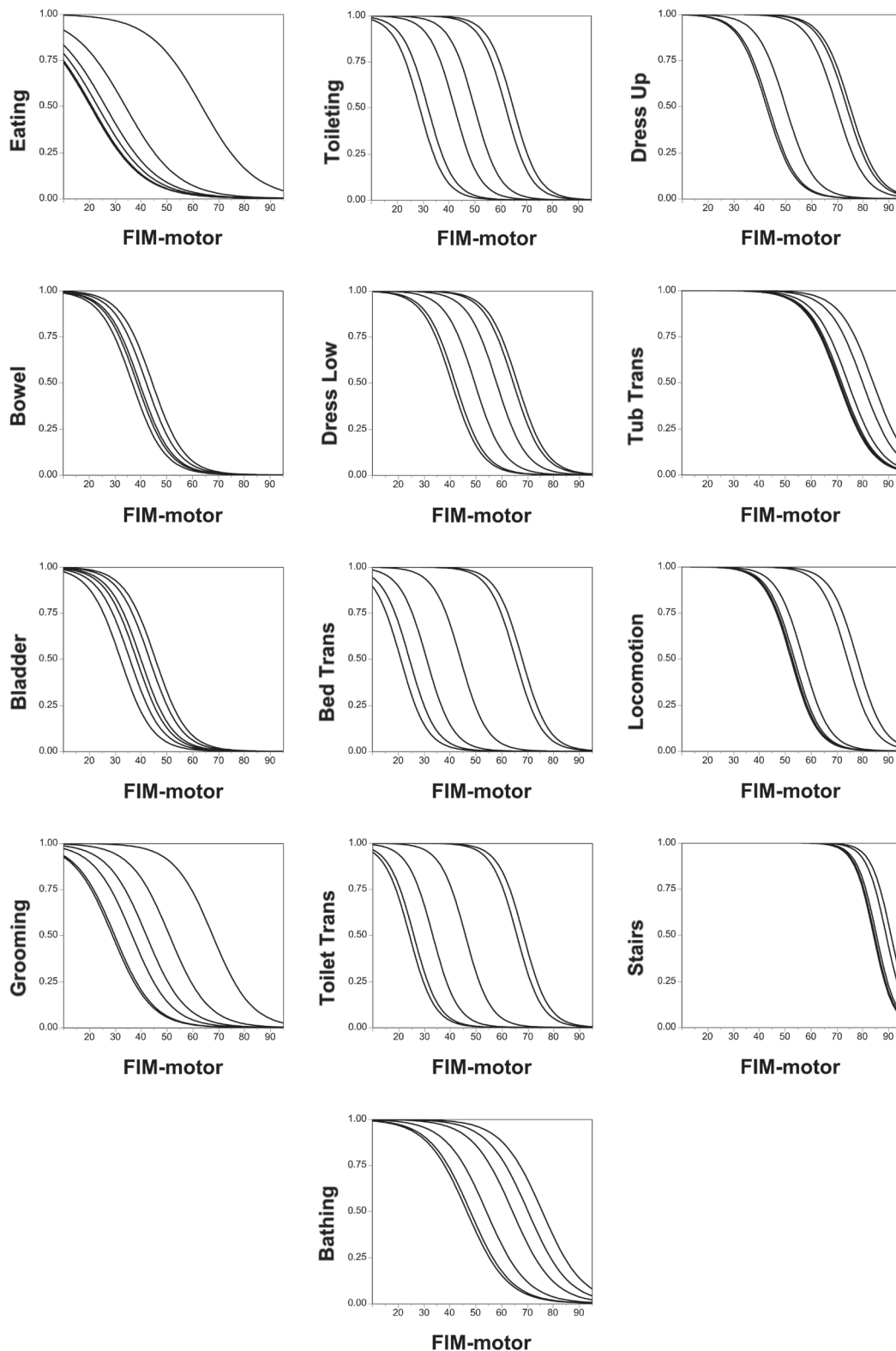


Fig. 2. Logistic probability plots of the relationships between total FIM-motor scores and independence levels of single motor FIM items (group data, total n = 500). The vertical axis shows logistic probability and the horizontal axis shows total FIM-motor scores. Probabilities are measured as the vertical distance between the curves. For example, the first (lower) curve shows the probability attributed to level 1. The next higher curve shows the probability attributed to level 2. Consequently, the distance between the first two curves is the probability for level 2. The distance from the top curve to the top of the graph is the probability attributed to level 7.

observation of patients treated in the SCU indicated that intravenous catheters located in the forearm for infusions and/or medications prevented the patients from dressing the upper body by themselves, resulting in minimal contact assistance (level 4) for this item. The logistic curves for bowel management data were condensed and displaced to the left (Fig. 2), indicating rapid recovery in the early phase for this item. In contrast, our previous findings obtained in patients in a long-term rehabilitation facility indicated a wide range for level 6 for the bowel management item.¹²⁾ This reflected a general weakness of the abdominal muscles among severe stroke patients and a consequent need to treat constipation with laxatives. Consequently, medical staff should be aware of the differences in the difficulty of FIM-motor items depending on the clinical setting.

This study has several limitations. First, as shown by the NIHSS data, most patients in this study had mild stroke severity. Careful consideration should be given when applying these findings to severe stroke patients treated in acute care settings. Further studies with severe stroke patients (e.g., classified by the NIHSS score) are needed to clarify this issue. Second, in this study, the data sampled at admission and on discharge were treated as one combined group. At the preliminary stage of this study, we performed separate analyses for the admission and the discharge subsets. However, the resulting relative item difficulties were very similar; this fact can be partly explained by the wide variety of clinical severity and length of hospital stay. Consequently, we focused on the concise method of data presentation shown here. Third, to minimize variability, we sampled data from patients who were independent in ADL before stroke. Subsequently, we excluded patients with commonly observed geriatric comorbidities (e.g., dementia). We thereby omitted nearly one-third of the total potential subjects from our final analytical database. Consequently, these findings should be applied cautiously to the general population. Fourth, the current study did not include patients with hemorrhagic stroke. Because such cases are often accompanied by disturbance of consciousness, assessment of FIM is not always feasible. Moreover, some hemorrhagic stroke patients need surgical removal of hematoma, resulting in delayed recovery compared with patients with ischemic stroke. Despite these limitations, this study underscored why FIM is one of the most widely used assessments tools in stroke rehabilitation, and the current analysis of the difficulty of FIM-motor items should prove useful in facilitating efficient rehabilitative treatment.

ACKNOWLEDGMENT

This study was partially supported by a Grant-in-Aid for Scientific Research (B), Japan Society for the Promotion of Science (JSPS KAKENHI [JP16H03209]).

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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