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ORIGINAL RESEARCH

# Clinical Prediction Rule for Declines in Activities of Daily Living at 6 Months After Surgery for Hip Fracture Repair

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**Abstract**

**Objectives:** To develop and assess a clinical prediction rule (CPR) to predict declines in activities of daily living (ADL) at 6 months after surgery for hip fracture repair.

**Design:** Prospective, cohort study.

**Setting:** From hospital to home.

**Participants:** Patients (N=104) with hip fractures after surgery.

**Interventions:** Not applicable.

**Main Outcome Measure:** ADL were assessed using the Barthel Index at 6 months after surgery.

**Results:** At 6 months after surgery, 86 patients (82.6%) were known to be alive, 1 patient (1.0%) had died, and 17 (16.3%) were lost to follow-up. Thirty-two patients (37.2%) did not recover their ADL at 6 months after surgery to levels before fracture. The classification and regression trees methodology was used to develop 2 models to predict a decline in ADL: (1) model 1 included age, type of fracture, and care level before fracture (sensitivity=75.0%, specificity=81.5%, positive predictive value=70.6%, positive likelihood ratio=4.050); and (2) model 2 included the degree of independence 2 weeks postsurgery for ADL chair transfer, ADL ambulation, and age (sensitivity=65.6%, specificity=87.0%, positive predictive value=75.0%, positive likelihood ratio=5.063). The areas under the receiver operating characteristic curves of both CPR models were .825 (95% confidential interval, .728−.923) and .790 (95% confidence interval, .683−.897), respectively.

**Conclusions:** CPRs with moderate accuracy were developed to predict declines in ADL at 6 months after surgery for hip fracture repair.

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The incidence of hip fracture has continued to increase among the ageing population.[1,2] Assuming that the age-related incidence will increase by only 1% per year, the number of hip fractures globally is expected to reach 8.2 million in 2050,[2] with approximately half of the patients unable to regain the ability to live independently.[3] In 1997, the direct and indirect annual costs of hip fracture treatment were estimated at $131.5 billion globally.[4] To prevent increased medical costs, health care providers should make efforts to identify persons at risk for declines in their activities of daily living (ADL) after discharge.

The following factors before or at the time of fracture have been associated with a decline in ADL at 6 months, 1 year, or 2 years after surgery: age[5-8]; ADL[5,8-10]; living in an institution at the time of injury[6,8]; the ability to shop for self or the degree of independent walking[7,11]; type of fracture[7]; concomitant diseases[12,13]; and cognitive impairment.[5,13] Predictors after fracture include a shorter hospital stay,[12] poor functional status,[6,11] poor mental status,[7,10] poor physical health,[7] need for a caregiver at discharge,[14] emotional support at 1 month after discharge,[15] impaired cognitive functioning,[16] and fear of falling[16] assessed 6 weeks after surgery. Although potential predictors before or after fracture have been widely investigated, the

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predictive accuracies of these factors to predict a decline in ADL after surgery remain unknown. Hence, individual predictors and in combination must be evaluated.

Various clinical prediction rules (CPRs) have been developed to identify the best combination of medical signs, symptoms, and other findings to predict the probability of a specific disease or treatment outcome.[17] CPRs provide health care providers with an evidence-based tool to assist in patient management. For example, the Harris hip score[18] was developed to assess the results of hip surgery or hip replacement. In addition, some CPRs have been developed for use in orthopedics. However, there is no CPR to predict the prognosis of ADL after surgery for hip fracture repair. Therefore, the purpose of this study was to develop and assess the accuracy of a CPR for the decline in ADL 6 months after surgery for hip fracture repair.

# Methods

## Study design

This prospective, cohort study of patients with hip fractures after surgery was approved by the ethics committees of the 2 hospitals where the participants were recruited (Chugoku Rousai Hospital [reference no. 2014-04] and Saiseikai Kure Hospital [reference no. 110], Kure, Japan) and the ethics committee of the university where the first author was affiliated (Hiroshima International University, Higashihiroshima, Japan [reference no. 14-118]). All study participants provided written informed consent.

## Setting

The study setting was the hospital and the patients' homes. Recruitment, follow-up, and data collection were performed between April 2013 and September 2015. The staff of the rehabilitation departments of the 2 hospitals recruited potential participants.

## Participants

Participants were included in the study if they (1) had sustained a fracture of their proximal femur; (2) had undergone a surgical procedure such as femoral head replacement; (3) were predominantly living independently indoors (degree of independent daily living for the disabled elderly of J or A; appendix 1); and (4) had some life-disturbing symptoms daily (ie, behavioral and communication problems) but could independently lead their daily life if watched by someone (independent daily living score for the elderly with dementia of I or II; appendix 2). Because cognitive impairment is another problem associated with locomotive impairment, we did not include elderly patients who had serious cognitive impairment before the fracture. The exclusion criteria were as follows: (1) the existence of hip fracture on the opposite side, and (2) multiple fractures. We prospectively collected patient information from 1 month before the fracture to 6 months after surgery. A total of 104 adults (25 men, 79 women; mean age ± SD, 80.8±10.5y) participated in this study.

***List of abbreviations:***

| | |
|---|---|
| **ADL** | **activities of daily living** |
| **AUROC** | **area under the receiver operating characteristic curve** |
| **CART** | **classification and regression tree** |
| **CPR** | **clinical prediction rule** |
| **CS-30** | **chair-stand-30** |
| **PLR** | **positive likelihood ratio** |
| **PPV** | **positive predictive value** |

## Variables

All potential predictors investigated were selected from the results of previous studies, which included prerehabilitation baseline data (age, sex, gait method, place of residence, ADL level, nursing care level, type of fracture, surgical method). Prerehabilitation data were collected during patient interviews at the start of rehabilitation by physical therapists (table 1). The type of fracture and surgical method were confirmed from medical records or by discussion with a physician.

ADL disabilities, chair-stand-30 (CS-30) test results, and pain intensity at 2 weeks after surgery were included as predictors. ADL disabilities during hospitalization were assessed, since such functional limitations during hospitalization were found to be strong predictors of mortality[17-23] and long-term care placement.[24-27] The Barthel Index[19] is an ordinal scale used to measure performance in ADL (ie, feeding oneself, bathing, dressing, grooming, and the ability to move) on a scale of 0 to 100 (0, very dependent; 100, independent). The scoring was based on objective assessments during hospitalization. The CS-30 test was used to assess functional lower extremity strength.[20] The 30-second chair test is administered using a folding chair without arms. At the signal "go," the participant rose to a full stand (body erect and straight) followed by returning to the initial seated position. Participants were encouraged to complete as many full stands as possible within 30 seconds and were instructed to completely sit between each stand. The scoring was based on the total number of stands within 30 seconds. Excellent test-retest and interrater reliability, and criterion validity of the CS-30 test have been reported.[20] Pain was assessed during the CS-30 test using a 100-mm visual analog scale. Data were collected at 2 weeks after surgery by the same therapist (see table 1).

Patients were followed up during the 6 months after surgery, and telephonic interviews were conducted to assess ADL disability using the Barthel Index, which is reportedly quite reliable.[21] Interviewers were blinded to patient characteristics at prefracture or during hospitalization. A decline in ADL was defined as a decrease at 6 months after surgery from that before the fracture, scored using the Barthel Index.

## Statistical analysis

The primary outcome was the Barthel Index total score at 6 months after surgery. In this study, the classification and regression tree (CART) methodology was used.[22] Binary trees are used to recursively split predictor variables with yes/no questions about each variable. Any type of statistical distributions can be handled, and it is not limited to linear relationships between outcome and predictor variables. These algorithms have been used to develop prediction models in various fields.[23-25] The CART methodology with the Gini index rule was used for the following 2 models: model 1, a prediction model using a prerehabilitation data set; and model 2, a prediction model using a data set of prerehabilitation and 2 weeks after surgery (see table 1). The pruning rule in the CART included bootstrapped V-fold cross-validation using the

**Table 1** Data set for developing CPRs

| Time | Variable Name | | Variable Type | Category |
|---|---|---|---|---|
| Prerehabilitation (baseline) | Age | | Continuous | |
| | Sex | | Categorical | Male, female |
| | Gait method before fracture | | Categorical | Independent gait/Crutch walking/Gait using a walker/Walking while holding on to something (such as a wall or table) |
| | Dwelling place before fracture | | Categorical | Home/institution |
| | ADL before fracture | Feeding | Ordinal | 0=unable; 5=needs help cutting, spreading butter, etc, or requires modified diet; 10=independent |
| | | Chair transfer | Ordinal | 0=unable, no sitting balance; 5=major help (1 or 2 people, physical), can sit; 10=minor help (verbal or physical); 15=independent |
| | | Grooming | Ordinal | 0=needs help with personal care; 5=independent face/hair/teeth/shaving (implements provided) |
| | | Toileting | Ordinal | 0=dependent; 5=needs some help, but can do something alone; 10=independent (on and off, dressing, wiping) |
| | | Bathing | Ordinal | 0=dependent; 5=independent (or in shower) |
| | | Ambulation | Ordinal | 0=immobile or <50yd; 5=wheelchair independent, including corners, >50yd; 10=walks with help of 1 person (verbal or physical) >50yd; 15=independent (but may use any aid; eg, stick) >50yd |
| | | Stair climbing | Ordinal | 0=unable; 5=needs help (verbal, physical, carrying aid); 10=independent |
| | | Dressing | Ordinal | 0=dependent; 5=needs help but can do about half unaided; 10=independent (including buttons, zips, laces, etc) |
| | | Bowel control | Ordinal | 0=incontinent (or needs to be given enemas); 5=occasional accident; 10=continent |
| | | Bladder control | Ordinal | 0=incontinent, or catheterized and unable to manage alone; 5=occasional accident; 10=continent |
| | Nursing care level before fracture | | Ordinal | 0=none; 1=needed support level 1; 2=needed support level 2; 3=care level 1; 4=care level 2; 5=care level 3; 6=care level 4; 7=care level 5 |
| | Type of fracture | | Categorical | Femoral neck/trochanteric/subtrochanteric |
| | Surgical form | | Categorical | Femoral head replacement/gamma nail or alexa nail/compression hip screw/osteosynthesis with plate |
| Second week after surgery | ADL | | Ordinal | |
| | Pain | | Continuous | |
| | CS-30 | | Continuous | |

minimum cross-validation error ± 1 standard error rule. A predicted rank was set by a positive likelihood ratio (PLR) of each subgroup. The accuracy of CART was evaluated using the area under the receiver operating characteristic curves (AUROCs) developed from each method. The maximum Youden Index (sensitivity + specificity − 1) was defined as the optimal cutoff point. The AUROC could distinguish between nonpredictive (AUROC<0.5), less predictive (0.5<AUROC<0.7), moderately predictive (0.7<AUROC<0.9), highly predictive (0.9<AUROC<1), and perfect prediction (AUROC=1).[26,27] Cases with missing data were included for analysis. For patients lost to follow-up (dropout), data were used only to compare patient characteristics before rehabilitation and 2 weeks after surgery. All statistical analyses were performed using Stata version 13 software for Windows.[a]

## Study size

Narita et al[28] reported that 76.4% of elderly Japanese patients (65–79y of age) without cognitive impairment fully recovered mobility after surgery for hip fracture. Based on this finding, we assumed that the ratio of negative to positive patients (ie, those with ADL decline at 6mo after surgery) was 3 (75%) to 1 (25%). The alpha value was set at .05, and the power was set at 0.8. The hypothesized AUROC and the null hypothesis AUROC were set at 0.7 (meaning moderate power) and 0.5 (meaning no discriminating power), respectively. Consequently, 22 cases were required in the positive group and 66 in the negative group, for a total of 88 cases.

# Results

At 6 months after surgery, 86 patients (82.6%) were known to be alive, 1 patient (1.0%) had died, and 17 (16.3%) were lost to follow-up. The reasons for discontinuation of follow-up were unclear because the investigators phoned the patients many times but were unable to make contact with the patients or their families.

Data were missing for ADL before fracture or 2 weeks after surgery (1 case), CS-30 (1 case), and pain intensity (2 cases). We did not perform imputation of missing data, and these cases were

**Table 2** Patient characteristics at prerehabilitation and 2 weeks after surgery

| Time | Variable | Category | All (N=104) | Completer (n=86) | Dropout (n=18) | *P* |
|---|---|---|---|---|---|---|
| Prerehabilitation (baseline) | Age (y) | | 80.8±10.5 | 80.8±10.0 | 80.7±13.1 | .957* |
| | Sex | Male | 25 (24) | 21 (24) | 4 (22) | .843† |
| | | Female | 79 (76) | 65 (76) | 14 (78) | |
| | Gait method before fracture | Independent gait | 67 (64) | 54 (63) | 13 (72) | .373† |
| | | Crutch walking | 13 (13) | 11 (13) | 2 (11) | |
| | | Gait using a walker | 6 (6) | 6 (7) | 0 (0) | |
| | | Walking while holding on to something (such as a wall or table) | 18 (17) | 15 (17) | 3 (17) | |
| | Dwelling place | Home | 91 (88) | 74 (86) | 17 (94) | .851† |
| | | Institution | 13 (13) | 12 (14) | 1 (6) | |
| | ADL before fracture | Total | 100 (40–100) | 100 (50–100) | 100 (40–100) | .686‡ |
| | Nursing care level before fracture | None | 61 (59) | 49 (57) | 12 (67) | .099† |
| | | Needed support level 1 | 9 (9) | 7 (8) | 2 (11) | |
| | | Needed support level 2 | 8 (8) | 7 (8) | 1 (6) | |
| | | Care level 1 | 16 (15) | 14 (16) | 2 (11) | |
| | | Care level 2 | 5 (5) | 4 (5) | 1 (6) | |
| | | Care level 3 | 5 (5) | 5 (6) | 0 (0) | |
| | | Care level 4 | 0 (0) | 0 (0) | 0 (0) | |
| | | Care level 5 | 0 (0) | 0 (0) | 0 (0) | |
| | Type of fracture | Femoral neck | 67 (64) | 56 (65) | 11 (61) | .140† |
| | | Trochanteric | 33 (32) | 27 (31) | 6 (33) | |
| | | Subtrochanteric | 4 (4) | 3 (3) | 1 (6) | |
| | Surgical form | Femoral head replacement | 53 (51) | 43 (50) | 10 (56) | .193† |
| | | Gamma nail or alexa nail | 39 (38) | 32 (37) | 7 (39) | |
| | | Hansson pin | 4 (4) | 4 (5) | 0 (0) | |
| | | Others | 8 (8) | 7 (8) | 1 (6) | |
| Two weeks after surgery | ADL | Feeding | 10 (5–10) | 10 (0–10) | 10 (5–10) | .814‡ |
| | | Chair transfer | 15 (0–15) | 15 (5–15) | 10 (0–15) | .266‡ |
| | | Grooming | 5 (0–5) | 5 (5–5) | 5 (0–5) | .984‡ |
| | | Toileting | 5 (0–10) | 5 (0–10) | 5 (0–10) | .851‡ |
| | | Bathing | 0 (0–5) | 0 (0–5) | 0 (0–0) | .153‡ |
| | | Ambulation | 10 (0–15) | 10 (0–15) | 10 (0–15) | .913‡ |
| | | Stair climbing | 0 (0–10) | 0 (0–10) | 0 (0–10) | .095‡ |
| | | Dressing | 5 (0–10) | 5 (0–10) | 5 (0–10) | .707‡ |
| | | Bowel control | 10 (0–10) | 10 (0–10) | 10 (0–10) | .435‡ |
| | | Bladder control | 10 (0–10) | 10 (0–10) | 10 (0–10) | .637‡ |
| | | Total | 60 (10–100) | 60 (10–100) | 65 (10–90) | .584‡ |
| | CS-30 | | 3.6±4.6 | 4.6±4.6 | 2.6±4.6 | .198‡ |
| | Pain | | 3.5±2.7 | 3.3±2.6 | 4.6±2.9 | .106‡ |

NOTE. Values are mean ± SD, n (%), median (minimum–maximum), or as otherwise indicated.
* Independent *t* test.
† Chi-square test.
‡ Mann-Whitney *U* test.

excluded from the CART model 1 or 2. There were no significant differences in patient characteristics at 2 weeks after surgery between those who completed the 6-month follow-up and those who did not. Other main characteristics are summarized in table 2. ADL were not recovered at 6 months after surgery, as compared with baseline, in 32 (37.2%) of the 86 patients who completed the follow-up.

For model 1 (fig 1), the CART method identified age (<81y or ≥81y) as the best single discriminator for a decline in ADL at 6 months after surgery. Among those aged ≥81 years, the next best predictor was "type of fracture (femoral neck vs trochanteric or intertrochanteric)." Among those with "type of fracture: femoral neck," the next predictor was age (<88y or ≥88y). Among those with "type of fracture: trochanteric or intertrochanteric," the next predictor was care level, dichotomized at "needed support level 1." The final tree model and 5 terminal nodes identified using CART analysis in model 1 are shown in figure 1 and table 3. The rank-1 group included 45.3% of patients (39/86), with a PLR of .248 and a positive predictive value (PPV) of 12.8%. The rank-2 group included 15.1% of patients (13/86), with a PLR of .506 and a PPV of 23.1%. The rank-3 group included 8.1% of patients (7/86), with a PLR of 1.266 and a PPV of 42.9%. The rank-4 group included 15.1% of patients (13/86), with a PLR of 3.797 and a PPV of 69.2%. The rank-5 group included 16.3% of patients (14/86), with a PLR of 10.125 and a PPV of 85.7%, which indicates excellent accuracy. Based on the

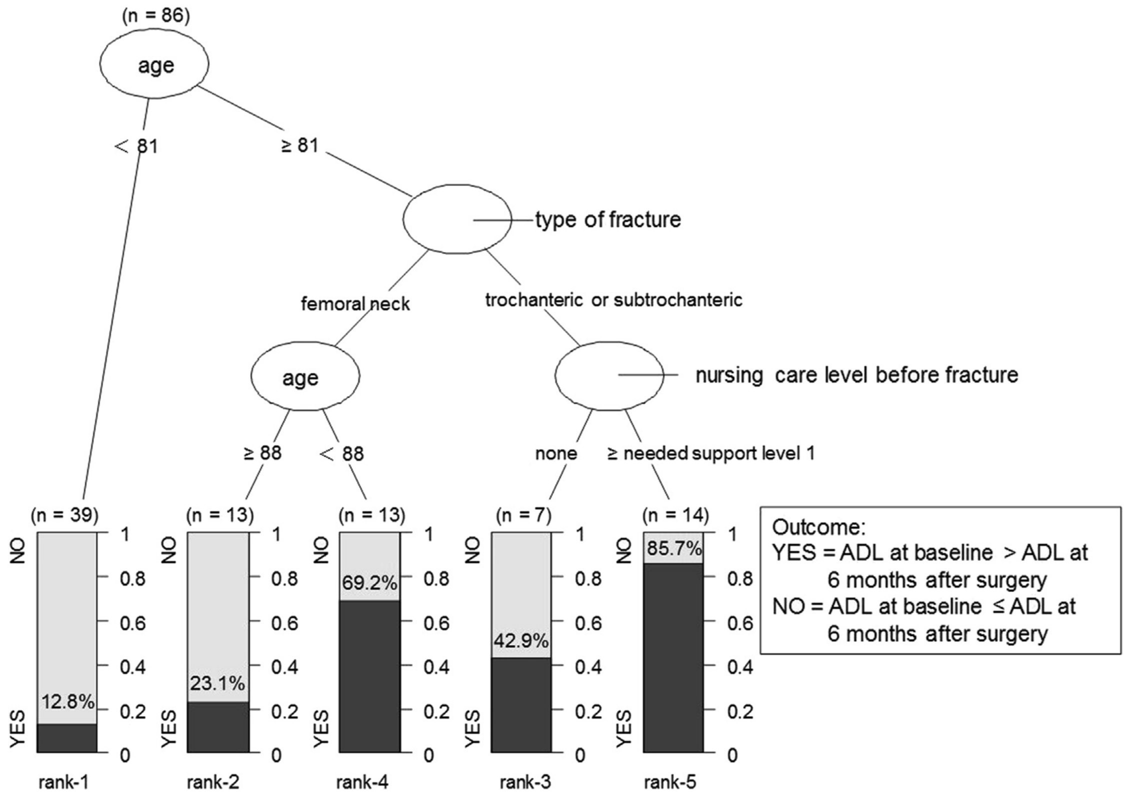


**Fig 1** CART model 1 using prerehabilitation data. The CART method identified "age" as the best single discriminator for a decline in ADL after surgery. Other predictors were "type of fracture" and "nursing care level before fracture."

AUROCs, the accuracy of the CART model 1 was .825 (95% confidence interval, .728−.923), with an optimal cutoff point of rank 3 or greater (sensitivity=75.0%, specificity=81.5%, PPV=70.6%, PLR=4.050).

For model 2 (fig 2), the CART method identified "postsurgery 2 weeks ADL chair transfer" (≤15) as the best single discriminator for the decline in ADL at 6 months. For those with a "postsurgery 2 weeks ADL chair transfer" of <15, the next best predictor was "postsurgery 2 weeks ADL ambulation (≥5 or <5)." Among those with a "postsurgery 2 weeks ADL ambulation" ≥5, the next predictor was age, dichotomized at 83 years. The final tree model for model 2 with the 4 terminal nodes identified by the CART analysis is shown in figure 2 and table 3. The rank-1 group included 55.8% of patients (48/86), with a PLR of .338 and a PPV of 16.7%. The rank-2 group included 11.6% of patients (10/86), with a PLR of .723 and a PPV of 30.0%. The rank-3 group included 14.0% of patients (12/86), with a PLR of 3.375 and a PPV of 66.7%. The rank-4 group included 18.6% of patients (16/86), with a PLR of 7.313 and a PPV of 81.3%. Based on the AUROCs, the accuracy of the CART model 2 was .790 (95% confidence interval, .683−.897), with an optimal cutoff point of rank 3 or greater (sensitivity=65.6%, specificity=87.0%, PPV=75.0%, PLR=5.063).

## Discussion

We developed and assessed a CPR to predict declines in ADL at 6 months after surgery for hip fracture repair. Therefore, these CPRs had moderate levels of accuracy.

Age,[5-8] type of fracture,[7] and ADL[5,8-10] before rehabilitation were significantly predictive of a decline in ADL at over 6 months after surgery for hip fracture repair. Although some studies have suggested the power of various factors to predict a decline in ADL, the accuracy of these predictions was not examined. We showed that age, type of fracture, and prerehabilitation ADL were predictors for a decline in ADL at 6 months after surgery, in accordance with the findings of previous studies.[5,7-10] Furthermore, we developed a CPR with a moderate precision for predicting a decline in ADL 6 months after surgery. CART analysis is useful to identify predictive factors while considering mutual relationships among factors with high contribution ratios. In this study, the best predictive factor identified by model 1 was age, followed by the type of fracture and nursing care level. Thus, elderly patients who have trochanteric or intertrochanteric fractures and who needed support for their ADL before the fracture are considered to be at a higher risk for a decline in ADL at 6 months after surgery. This reliable CPR should prove useful to rehabilitation therapists to screen for patients who are at greater risk for a decline in ADL after surgery.

Most previous studies did not identify factors during hospitalization to predict ADL decline at over 6 months after surgery. Therefore, rehabilitation therapists have limited information on what factors should be targeted to prevent a decline in ADL after discharge. The model 2 results showed that the level of independent chair transfer and ambulation, as assessed using the Barthel Index at 2 weeks after surgery, and age are significant predictive factors for the recovery of ADL. In addition, the precision of model 2, as well as model 1, was supported by a high PLR and AUROC. Although health care providers cannot control age, type of fracture, or nursing care level before rehabilitation, the level of independence in performing a chair transfer and in ambulating at 2 weeks after surgery may be improved by early intervention through rehabilitation

**Table 3** Accuracy of CART models and CPRs

| CPRs | Sensitivity | Specificity | PPV | NPV | PLR | AUROC (95% CI) | Optimal Cutoff Point |
|---|---|---|---|---|---|---|---|
| CART model 1: Prerehabilitation data (see fig 1) | .750 | .815 | .706 | .154 | 4.05 | .825 (.728—.923) | ≥ Rank 3 |
| Rank 1 "Age" <81 | .156 | .370 | .128 | .574 | 0.248 | | |
| Rank 2 "Age" ≥88 and "type of fracture" femoral neck | .094 | .815 | .231 | .397 | 0.506 | | |
| Rank 3 "Age" ≥81 and "type of fracture" trochanteric or subtrochanteric and "nursing care level before fracture" none | .094 | .926 | .429 | .367 | 1.266 | | |
| Rank 4 "Age" ≥81 and <88 and "type of fracture" femoral neck | .281 | .926 | .692 | .315 | 3.797 | | |
| Rank 5 "Age" ≥81 and "type of fracture" trochanteric or subtrochanteric and "nursing care level before fracture" ≥ needed support level 1 | .375 | .963 | .857 | .278 | 10.125 | | |
| CART model 2: Prerehabilitation data + data of 2nd week after surgery (see fig 2) | .656 | .870 | .750 | .190 | 5.063 | .790 (.683—.897) | ≥ Rank 3 |
| Rank 1 "ADL chair transfer 2nd week after surgery" = 15 | .250 | .259 | .167 | .632 | 0.338 | | |
| Rank 2 "ADL chair transfer 2nd week after surgery" <15 and "ADL ambulation 2nd week after surgery" ≥5 and "age" <83 | .094 | .870 | .300 | .382 | 0.723 | | |
| Rank 3 "ADL chair transfer 2nd week after surgery" <15 and "ADL ambulation 2nd week after surgery" ≥5 and "age" ≥83 | .250 | .926 | .667 | .324 | 3.375 | | |
| Rank 4 "ADL chair transfer 2nd week after surgery" <15 and "ADL ambulation 2nd week after surgery" <5 | .406 | .944 | .813 | .271 | 7.313 | | |

NOTE. Optimal cutoff point was determined using Youden Index.
Abbreviations: CI, confidence interval; NPV, negative predictive value.

programs. Along with the development of a CPR, we identified the cutoff values of predictors using CART analysis. We believe that in early rehabilitation, these values should be targeted at 2 weeks after surgery.

Internationally, CART has become increasingly prevalent because of the sentinel work by Breiman et al.[29] CART is an exploratory research method to uncover relationships and produce clearly illustrated associations between variables not amenable to traditional linear regression analysis.[30] This method has a long history in market research and has more recently become increasingly used in medicine to stratify risks[31] and determine prognoses.[32] A literature review of studies that used CART revealed relatively few studies, with only 1 study[33] written in Japanese. Compared with the statistical methods used in previous studies, our proposed novel approach is expected to be used in future studies for the development of CPRs.

Generally, the elderly are at a greater risk of femoral neck fractures and mild walking disabilities, and some may have cognitive impairments. If possible, data should be collected from various patients to generalize CPRs developed by this study. However, cognitive impairment is another problem associated with locomotive impairment. Accordingly, we targeted elderly patients with femoral neck fractures, independent locomotion, and no serious cognitive impairment before fracture. Hence, our study findings can be generalized to patients who meet our inclusion criteria with neither of the exclusion criteria. In addition, our investigation period was 6 months. It is unknown whether these findings can be applied to predict a decline in ADL over 6 months after surgery. We continue to follow-up the study participants for further verification of this model in future studies.

## Study limitations

There were several limitations to this study that should be addressed. First, there was a potential selection bias because patients with serious complications immediately after surgery may have hesitated to participate in this study, compared with those who fared better. Patients with serious complications immediately after surgery are most likely to recover more slowly, with ADL levels at 6 months after surgery lower than those before fracture. In general, this tendency is particularly prevalent among elderly patients. The results of this study identified age as a risk factor for a decline in ADL at 6 months after surgery in both CPR models 1 and 2. If this bias could be reduced, the number of patients not recovering ADL would increase, and both PPV and PLR would positively change. Second, the strength of confounding factors on our results was not adjusted. We believe this limitation is not important because CART analysis considers mutual relationships among factors included in the decision tree model. However, this study did not address psychological factors such as mental status[7,10] and fear of falling,[16] which have already been confirmed as risk factors for a decline in ADL. Although the predictors used were selected based on the results of previous studies, these studies may not have included all possible predictors. For example, it appears as though psychosocial variables have not been adequately explored. Alternative CPRs that include these factors may be more accurate than CPRs proposed in the present study. Another possible limitation was the scoring method of the Barthel Index. The scoring was based on objective assessments during hospitalization, but on self-reports at 6 months after surgery. Thus, there may have been a reporting bias in our data. To

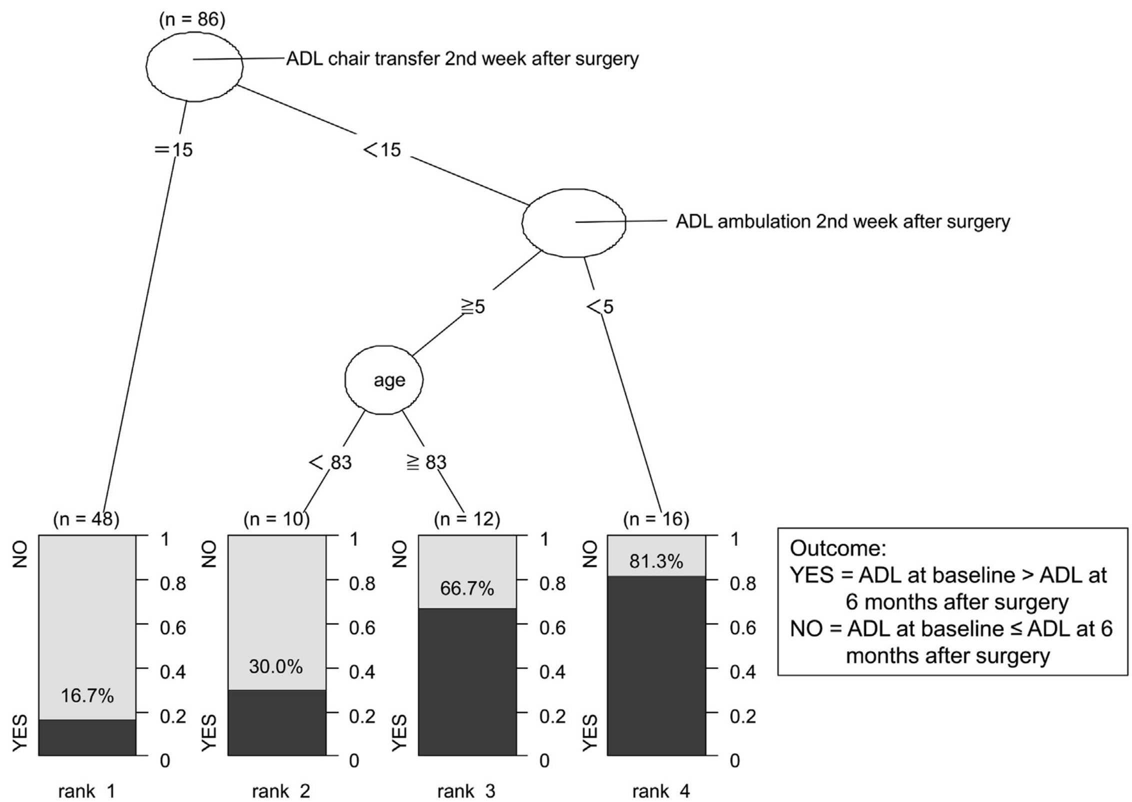


**Fig 2** CART model 2 using prerehabilitation data plus data from 2nd week after surgery. The CART method identified "ADL chair transfer 2nd week after surgery" as the best single discriminator for a decline in ADL after surgery. Other predictors were "ADL ambulation after 2nd week after surgery" and "age."

minimize this bias, in future studies, the method for scoring the Barthel Index should be integrated with objective assessment by the same trained assessor.

## Conclusions

CPRs with moderate accuracy were developed to predict declines in ADL at 6 months after surgery in patients with hip fractures. These CPRs are reliable and is worthwhile for the screening of patients at a greater risk of ADL decline after surgery. For preventing the ADL decline, elderly patients who have trochanteric or intertrochanteric fractures and who needed support for their ADL before the fracture should receive more intensive rehabilitation, more timely rehabilitation, or both, to recover their ability to chair transfer and ambulate by 2 weeks after surgery.

## Supplier

a. Stata version 13 software for Windows; StataCorp LP.

## Keywords

Activities of daily living; Hip fractures; Prognosis; Rehabilitation

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# Appendix

**Appendix 1** Independence Degree of Daily Living for the Disabled Elderly

| | |
|---|---|
| Rank J | Some disabilities, but daily living is mostly independent; capable of going outdoors unassisted. |
| | 1. Goes outdoors with means of transportation. |
| | 2. Goes out near home. |
| Rank A | Indoor living predominantly independent, but unable to go out without assistance. |
| | 1. Goes out with assistance, spending most time during the daytime out of bed. |
| | 2. Does not go out frequently, repeating cycles of lying down on and getting up from a bed during the daytime. |
| Rank B | Some assistance needed for indoor living; also lies in bed for much of the daytime, although sitting position is possible. |
| | 1. Uses a wheelchair without assistance, takes meals, and excretes/urinates off the bed. |
| | 2. Uses a wheelchair with assistance. |
| Rank C | Bedridden all day; requires assistance with excretion/urination, meals, and dressing/undressing. |
| | 1. Capable of changing posture in bed. |
| | 2. Unable to change posture in bed without assistance. |

**Appendix 2** Independence Degree of Daily Living for the Elderly With Dementia

| | |
|---|---|
| Rank I | Has some type of dementia, but almost independent in terms of daily living at home and in society. |
| Rank II | Some daily life-disturbing symptoms, behaviors, and problems in communication seen, but can lead daily life independently if watched by someone. |
| IIa | Condition II, mentioned above, seen outside home. |
| IIb | Condition II, mentioned above, seen at home. |
| Rank III | Daily life-disturbing symptoms, behaviors, and problems in communication that require assistance. |
| IIIa | Condition III, mentioned above, seen primarily during the daytime. |
| IIIb | Condition III, mentioned above, seen primarily at night. |
| Rank IV | Daily life-disturbing symptoms, behaviors, and problems in communication frequently require assistance. |
| Rank M | Marked psychiatric symptoms/related symptoms or serious physical disorders require expert management. |

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