Rehabilitation after lower limb injury: development of a predictive score (RALLI score)

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Background: The purpose of our study was to identify the risk factors associated with the need for inpatient rehabilitation after lower limb injury to develop a predictive scoring tool for early identification of such patients.

Methods: We followed a prospective cohort of patients admitted to a level 1 trauma centre. Data were collected through chart review and a self-administered questionnaire on sociodemographics, patient living environment, pretrauma status, injury and treatment received. We compared patients who were discharged home with those going to rehabilitation after acute care. Analysis consisted of bivariate comparisons and logistic regression.

Results: Our study included 160 patients with a mean age of 56 years. A total of 40% were discharged to an inpatient rehabilitation centre. Factors associated with inpatient rehabilitation were low preinjury physical health status, concomitant injury of the upper limbs, bilateral lower limb injury, the use of a walking aid before injury, head injury and femur or pelvic fractures. We created a predictive score using the top 3 risk factors: upper limb injury, bilateral lower limb injury and presence of femoral or pelvic fractures. The chance of needing inpatient rehabilitation rose from 14% with 0 factors to 47% with 1 factor and 96% with 2 factors.

Conclusion: Rehabilitation planning should begin for patients exhibiting at least of 3 risk factors at the time of admission to acute care. Prospective validation of the tool is needed, but it has the potential to orient the multidisciplinary team's decision on rehabilitation needs postdischarge.

Contexte : Notre étude avait pour but de recenser les facteurs de risque associés à un séjour en établissement de réadaptation pour les patients victimes de traumatismes aux membres inférieurs, afin de concevoir un outil de classification prédictive pour l'identification précoce de ces patients.

Méthodes : Nous avons suivi une cohorte prospective de patients admis dans un centre de traumatologie de niveau 1. Les données proviennent d'une revue des dossiers et de questionnaires auto-administrés sur les caractéristiques sociodémographiques, le milieu de vie des patients, leur statut prémorbide, le traumatisme subi et le traitement reçu. Nous avons comparé les patients qui ont reçu leur congé pour retourner à la maison à ceux qui devaient faire un séjour en centre de réadaptation après des soins actifs. L'analyse a reposé sur des comparaisons bivariées et la régression logistique.

Résultats : Notre étude a regroupé 160 patients âgés en moyenne de 56 ans. En tout, 40 % ont été transférés dans des centres de réadaptation où ils ont séjourné. Les facteurs associés au transfert dans un centre de réadaptation étaient : piètre état de santé physique avant le traumatisme, traumatisme concomitant aux membres supérieurs, traumatisme aux 2 membres inférieurs, utilisation d'un dispositif d'aide à la marche avant le traumatisme, traumatisme crânien et fractures du fémur ou du bassin. Nous avons créé un score prédictif sur la base des 3 principaux facteurs, soit traumatisme concomitant aux membres supérieurs, traumatisme aux 2 membres inférieurs et fractures du fémur ou du bassin. Le risque de devoir séjourner en centre de réadaptation est passé de 14 % en l'absence de ces facteurs à 47 % en présence de l'un des facteurs et à 96 % en présence de 2 facteurs.

Conclusion : La planification de la réadaptation devrait commencer dès leur admission en centre de soins actifs pour les patients qui présentent au départ au moins 3 facteurs de risque. Il faudra valider l'outil de façon prospective, mais il pourrait orienter les décisions de l'équipe multidisciplinaire quant aux besoins de réadaptation lorsque le patient reçoit son congé.

Lower limb injuries account for up to 38% of all serious injuries.[1] Ambulatory limitation following these injuries prevents a large number of patients from returning home rapidly. Furthermore, a substantial proportion of patients continue to have disabilities, and after 1 year 50% of patients with lower limb trauma have not regained their preinjury level of function.[2] Ponsford and colleagues[3] showed that only 54% of patients admitted for orthopedic trauma were back at work 1 year posttrauma. Rehabilitation needs remain a crucial element of recovery that could be improved. Often, to determine what kind of rehabilitation is needed for patients after acute care, a multidisciplinary team composed of a physiotherapist, occupational therapist, social worker, nurse and physician is needed. This team analyzes a multitude of factors, including patient characteristics, trauma severity, home description and social support.[4] The final decision of whether a patient can be discharged home is made after a concerted professional health care evaluation, which can take several days, extends length of stay in hospital (LOS) and consumes important health care resources. Poulos and colleagues[5] reported that 45% of inappropriate days in acute care were due to delays in this decision process. As cost containment and evidence-based orthopedics are becoming increasingly important, reliable tools and valid measures are required to optimize rehabilitation and to reduce costs.

Optimally, the need for rehabilitation should be predicted as soon as possible after the patient is admitted in order to avoid undesirable delays in discharge planning. Similar challenges have been encountered with the joint replacement surgical population leading to the development of the "fast track" philosophy with an increased rate of discharge home rather than to the rehabilitation centre.[6,7] Significant decreases in length of stay were obtained in multiple studies based on this type of approach.[8,9] Clay and colleagues[10] highlighted the need for more prospective studies with methodologies that have larger sample sizes and that consider a comprehensive range of factors to predict autonomy after injury.

Factors that typically predict rehabilitation needs include age, premorbid level of activity, obesity, injury severity and certain comorbid medical conditions.[2,11–17] Despite the complexities involved with a heterogeneous trauma population, we believe it is possible to develop a systematic tool to help determine the patient's need for rehabilitation after lower limb injury. Therefore, the aim of our study was to develop a predictive score of inpatient rehabilitation needs after lower limb injury, and the secondary objective was to explore factors associated with acute care LOS.

Methods

We conducted a prospective cohort study that included all patients older than 18 years who were admitted to a level 1 trauma centre for lower limb injury between August 2011 and September 2012. Patients had to stay a minimum of 1 night in the orthopedics ward to be considered hospitalized. We defined lower limb injury as a fracture or clinically important soft tissue injury affecting structures from the pelvis to the toes. Patients who had simple lower limb trauma without hospitalization (e.g., an ankle fracture, including those treated by open reduction and internal fixation on an ambulatory basis) were excluded. We also excluded patients with pathologic fractures, those who were unable to communicate and those with previous lower limb surgery. The hospital research ethics board approved the study, and all participants signed an informed consent form.

Based on the determinants that affect rehabilitation needs after surgery that have been previously identified in the literature,[2,7-10,12-14,18] we hypothesized that the following factors could potentially determine the need for inpatient rehabilitation: preinjury functional status, injury severity, surgical treatment, age, sex, distance between home and hospital and socioeconomic status. We also collected the following data from the patient's file: patient and injury characteristics, time of injury, admission, hospital discharge and destination after acute care hospitalization. Patients completed questionnaires that described function preinjury (Lower Extremity Measure [LEM]), health status (SF-12 version 2 [SF12V2]) and sociodemographic information. Preinjury functional status was assessed with medical history and included the number of stairs inside and outside the home, the type of residence (home, apartment, nursing home, prison) and the use of walking aids. We also collected information on body mass index (BMI) — calculated from height and weight as reported by the patient — and smoking status, which may be correlated with a longer hospitalization as it is associated with medical complications.[19,20] Injury severity characteristics included isolated trauma or polytrauma, upper limb involvement, open or closed fracture, trauma associated with head injury, surgical versus conservative treatment, trauma above or below the knee, time between injury and hospital admission and time between admission and surgery. Socioeconomic status was characterized by employment status (unemployed, employed, retired, autonomous worker, student, other), marital status (married, divorced, single, widower) and patient insurance (none, provincial automobile insurance plan, workers compensation, private insurance). The distance between the home and hospital was calculated using Google Maps and the patient's postal code. The LEM, a questionnaire for which a normal functional score is 85 or higher and that has been validated in the orthopedic population,[21] was used to assess preinjury lower limb functional status. For assessment of their general health status, patients completed the SF12V2,[22] which has also been validated in trauma patients.[23] We estimated that we would need a sample size of 160 patients to create a regression model with 5–7 factors using the rule of thumb of 20 patients per predictor.[24]

Statistical analysis

Primary analysis: rehabilitation needs

We classified patients in 2 groups: patients going directly home after acute care and patients who were discharged to inpatient rehabilitation in another centre. We compared these groups in terms of age, number of stairs at home, LOS, LEM and SF12V2 scores using *t* tests. We used χ^2 tests to compare them with respect to sex, employment status, marital status, smoking status, use of walking aids, fracture versus soft tissue injury, number of injuries (> 1 v. 1), presence of head injury, unilateral versus bilateral lower limb injury, presence of upper limb injury, surgical treatment, pelvis versus other lower limb injury, femur injury versus other injury and open versus closed fracture. We considered results to be significant at $p < 0.05$.

We constructed a step-wise logistic regression model, entering age, sex and any factor ($p < 0.05$) associated with discharge to inpatient rehabilitation in the bivariate analysis. A prospective score of 3 items was built using the factors whose odds ratios (ORs) remained significant in the regression analysis.[25] The score was tested on the database to determine a threshold for prediction of rehabilitation needs using the PASW version 18.0 software for statistical analyses.

Secondary analysis

In order to achieve our second objective, we analyzed the factors related to LOS in acute care. We conducted a bivariate analysis between potential risk factors (the same as those for the rehabilitation needs analysis described previously) and increased LOS (in days) using Pearson correlations for continuous data and Student *t* tests for dichotomous variables. We considered results to be significant at $p < 0.05$.

Results

During our study period, 301 potential patients were identified: 160 agreed to participate and 141 were not included (Fig. 1). Reasons for nonparticipation or exclusion were missed patients (n = 69), refusal (n = 41), cognitive impairment (n = 12), severe head injury (n = 6), language barrier (n = 5), isolation for resistant germs (n = 3), pathologic fracture (n = 2), previous lower limb surgery (n = 2) and rheumatoid arthritis (n = 1). Participants were younger than nonparticipants (56 v. 64 yr, p = 0.002), but did not otherwise differ. The sample included 84 men (53%). The mean age of patients was 56 years, and 26% were 70 years or older. A description of the cohort is provided in Table 1, Table 2 and Table 3.

Bivariate analysis revealed that the following factors were associated with inpatient rehabilitation: polytrauma, bilateral lower limb injury, pelvic injury, femoral injury, upper limb and head injury and use of a walking aid before injury (Table 4); these factors increased the risk of inpatient rehabilitation from OR 2.4 to OR 7.3. Patients who underwent

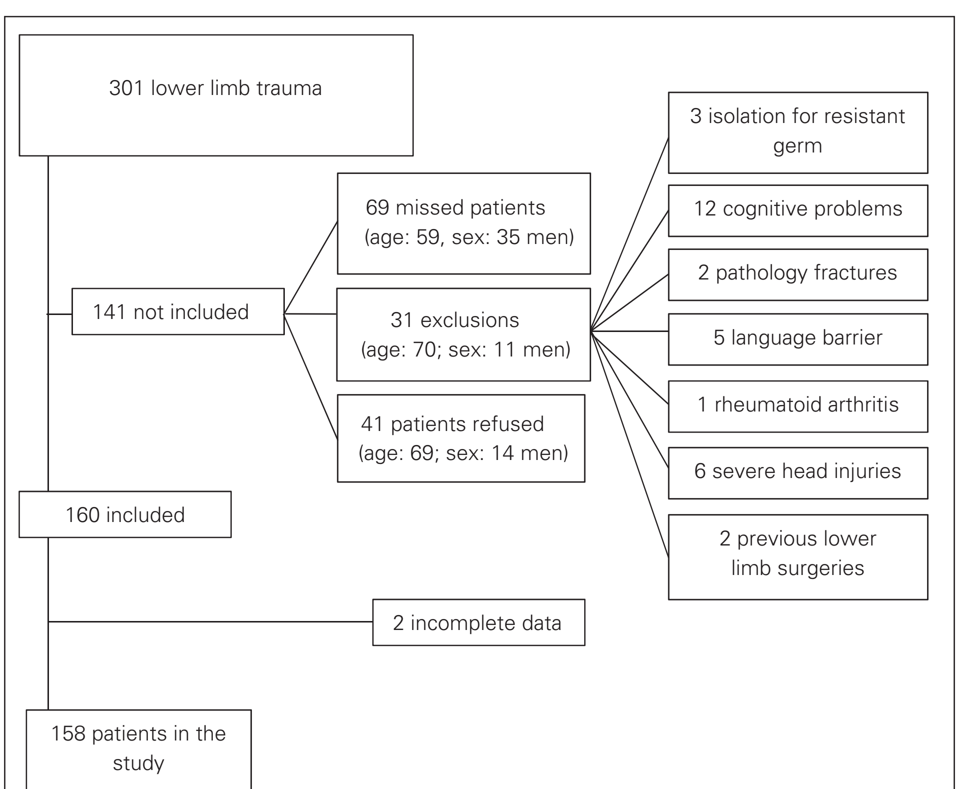

Fig. 1. Participant selection.

rehabilitation also had a lower preinjury SF12 physical score (47 ± 15 v. 52 ± 10, $p = 0.031$).

The stepwise logistic regression model was built using 0.05 or lower as an entry value and 0.1 as an exit value. As described in the analysis section, we forced age and sex into the model and then used step-wise methodology. In the final logistic regression model, the following factors were retained: bilateral lower limb injury, upper limb injury and femur or pelvis fracture (Table 5).

The 3 factors that predicted inpatient rehabilitation were assessed. If none were present, the risk of inpatient rehabilitation was only 14%. When 1 factor was present, depending on which one, the risk increased between 41% and 53%, and with 2 factors present it increased between 79% and 86% (Table 6). Based on this data, we constructed a simple decision tool; the presence of at least 2 factors (score of 2) would indicate referral to inpatient rehabilitation.

With respect to our secondary objective, patients needing rehabilitation stayed longer in hospital (16 v. 11 d, $p = 0.011$). Factors affecting LOS in acute care were decreased preinjury LEM score, bilateral lower limb injury, upper limb injury and use of a walking aid before injury (Table 7).

Discussion

We determined that bilateral injury, upper limb injury and femur or pelvic fractures were strong predictors for inpatient rehabilitation following hospital admission for lower limb injury, and we developed a simple tool to predict the need for inpatient rehabilitation after lower limb injury. Although this tool will need to be validated, it has the potential to help the medical team determine early during the hospital admission the required postdischarge care. Our bivariate analysis findings agree, for the most part, with the literature. Oldmeadow and colleagues[26] determined that for patients undergoing hip or knee arthroplasty, older age and use of a walking aid were predictive of extended inpatient rehabilitation. Our results indicated that bilateral limb injuries and concomitant injury of the upper limbs were associated with inpatient rehabilitation; both these factors led to greater challenges for renewed mobility and thus the potential need for rehabilitation strategies. Polytrauma patients, owing to the more severe nature of their injuries, are more likely to have greater functional limitations and therefore greater rehabilitation needs. Clearly, ambulatory capacities play a decisive role regarding the need for inpatient rehabilitation. Similarly, the use of a walking aid before injury suggests a more fragile premorbid state and reduced adaptive capabilities postoperatively. Severity of injury, preinjury disability and pelvic or femur fractures were also identified as factors affecting inpatient rehabilitation needs and disability after trauma.[8,27]

This study marks, to our knowledge, the first step toward the development of a scoring system that could guide discharge of lower limb trauma patients as early as possible. Strengths of the study include its prospective

Table 1. Cohort description

Characteristic	No. (%) of patients or mean ± SD (range)
Walking aid preinjury	20 (16)
Tobacco	41 (26)
Retired	51 (32)
Polytrauma	50 (32)
Upper limb injury	24 (15)
Bilateral lower limb injury	26 (16)
Head injury	19 (12)
Conservative treatment	19 (12)
Femur fracture	41 (26)
Pelvic fracture	32 (20)
Age, yr	56 ± 20 (18–89)
Male sex	84 (53)
Distance from the hospital, km	43 ± 101 (0–615)
LEM score preinjury	92 ± 16 (22–100)
SF12 physical score preinjury	50 ± 12 (0–66)
SF12 mental score preinjury	54 ± 10 (0–70)

LEM = Lower Extremity Measure; SD = standard deviation; SF12 = Short-Form 12 version 2.

Table 2. Comparison of patients included and excluded

	No. (%) of patients or mean ± SD (range)		
Characteristic	Included, *n* = 160	Missed/excluded, *n* = 141	*p* value
Age, yr*	56 ± 20 (18–89)	64 ± 24 (18–101)	0.002
Male sex†	84 (53)	60 (43)	0.08
Polytrauma†	50 (31)	36 (26)	0.06

SD = standard deviation.
*Student *t* test.
†χ^2 test.

Table 3. Description of fractures (*n* = 191)*

Location of the fractures	No. (%)
Pelvic	32 (17)
Hip	18 (10)
Femur diaphysis	6 (3)
Distal femur	9 (5)
Patella	3 (2)
Proximal tibia	13 (7)
Tibia diaphysis	35 (18)
Ankle	52 (27)
Foot	21 (11)

*Twenty-seven patients had multiple fractures.

Table 4. Predictors of inpatient rehabilitation need (bivariate analysis)

Factor	OR (95% CI)	*p* value
Polytrauma	4.9 (2.4–10.0)	< 0.001
Bilateral lower limb injury	7.3 (2.8–19.5)	< 0.001
Pelvis injury	4.5 (2.0–10.4)	< 0.001
Femur injury	2.4 (1.2–5.0)	0.015
Upper limb injury	5.4 (2.1–13.7)	< 0.001
Head injury	3.8 (1.4–10.7)	0.007
Walking aid preinjury	3.3 (1.3–8.3)	0.009

CI = confidence interval; OR = odds ratio.

nature, use of both patient questionnaire and medical file data and a stable multidisciplinary team for the entire data collection period. Furthermore, the scoring system is simple and can be used at an early stage of the hospitalization process.

Limitations

Challenges of the study included avoiding recruitment bias. Nonparticipants were older than participants but were not otherwise significantly different; however, this may have led to an underestimation of the association between age and inpatient rehabilitation needs. Validation of this tool is also needed before suggesting its use elsewhere, as the results are most pertinent to the centre where the research was performed. Finally, there may be a problem with generalizability to other acute care. Further research using the tool in other health centres is needed.

Table 5. Predictors of need for inpatient rehabilitation after lower limb injury

Factor	OR (95% CI)	*p* value
Bilateral lower limb injury	7.2 (2.2–23.1)	0.001
Concomitant upper limb injury	4.4 (1.3–14.3)	0.015
Femur or pelvic fracture	5.6 (2.4–13.0)	< 0.001

CI = Confidence interval; OR = odds ratio.

Table 6. RALLI score

No. of factors	Factors: Concomitant upper limb injury	Factors: Femur or pelvic fracture	Factors: Bilateral lower limb injury	Risk of inpatient rehabilitation	Mean risk
0/3	0	0	0	14%	14%
1/3	1	0	0	41%	47%
	0	1	0	47%	
	0	0	1	53%	
2/3	1	1	0	79%	83%
	1	0	1	83%	
	0	1	1	86%	
3/3	1	1	1	96%	96%

RALLI = rehabilitation after lower limb injury.

Table 7. Factors increasing length of stay

Factor	LOS; mean ± SD, d*† Yes	LOS; mean ± SD, d*† No	*p* value
Bilateral injury	18 ± 9	12 ± 12	0.007
Upper limb injury	18 ± 9	12 ± 12	0.007
Walking aid preinjury	18 ± 22	12 ± 9	0.016
LEM preinjury, Pearson correlation coefficient	$r = -0.274$		0.001

LEM = Lower Extremity Measure; LOS = length of stay in hospital; SD = standard deviation.
*Unless indicated otherwise.
†Student *t* test.

Conclusion

Through a prospective study using a cohort of patients hospitalized for lower limb injuries, we found that having bilateral lower limb injury, a concomitant upper limb injury, or polytrauma increases the risk of requiring inpatient rehabilitation by 3–7 times. The tool that we created can be used to screen patients who are likely to require inpatient rehabilitation after acute care and consists of 3 factors: bilateral injury, upper limb injury and femur or pelvic fractures. This information can be used to accelerate discharge planning to the appropriate resource. Additional study is required to determine if this new scoring system results in a reduction of LOS and in improved care efficiency. Application of the tool in another centre could be an interesting way to further the investigation.

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