A Simplified Scoring Tool for Prediction of Readmission in Elderly Patients Hospitalized in Internal Medicine Departments

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ABSTRACT: **Background:** Frequent readmissions significantly contribute to health care costs as well as work load in internal medicine wards.
Objective: To develop a simple scoring method that includes basic demographic and medical characteristics of elderly patients in internal medicine wards that would allow prediction of readmission within 3 months of discharge.
Methods: We conducted a retrospective observational study of 496 hospitalized patients using data collected from discharge letters in the computerized archives. Univariate and multivariate logistic regression analyses were performed and factors that were significantly associated with readmission were selected to construct a scoring tool. Validity was assessed in a cohort of 200 patients.
Results: During a 2 year follow-up 292 patients were readmitted at least once within 3 months of discharge. Age 80 or older, any degree of impaired cognition, nursing home residence, congestive heart failure, and creatinine level › 1.5 mg/dl were found to be strong predictors of readmission. The presence of each variable was scored as 1. A score of 3 or higher in the derivation and validation cohorts corresponded with a positive predictive value of 80% and 67%, respectively, when evaluating the risk of rehospitalization.
Conclusions: We propose a practical, readily available five-item scoring tool that allows prediction of most unplanned readmissions within 3 months. The strength of this scoring tool, as compared with previously published scores, is its simplicity and straightforwardness.

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KEY WORDS: readmission, rehospitalization, elderly, prediction tool

Frequent readmissions have become a major problem of chronically ill patients hospitalized in internal medicine wards [1]. In the setting of overcrowded medical departments and prolonged lengths of stay, rehospitalizations are a significant contributor to health care costs and work load [2]. Correct assessment of the patient's condition and the risk of readmission may improve the physician's approach to the patient and define better treatment endpoints to reduce the rate of readmissions.

Many scoring methods have been suggested to assess severity of illness and predict unplanned readmission, such as the Cumulative Illness Rating Scale [3,4]. However, this score is too detailed and complex. Van Walraven et al. [5] constructed the LACE index, which includes length of stay, acuity of the admission (emergency), comorbidities (measured with the Charlson Comorbidity Index) and previous emergency department visits before readmission. This index was accurate in predicting death or unplanned readmission within 30 days after discharge from hospital to the community, but the cohort included only cognitively intact patients and patients from both surgical and medical wards. The patients at risk for rehospitalization algorithm [6] is useful for predicting emergency readmissions within one year but is relatively complex and relies on a computerized database that is unavailable in most countries. Roughly, readmission could not be anticipated in at least one-third of hospitalized patients regardless of the model. The aim of this observational study was to develop a simple and readily available scoring method that would allow reasonable prediction of short-term readmission.

SUBJECTS AND METHODS

We reviewed the data of 930 patients from three medical wards in a 700 bed teaching hospital over a 2 year period during the years 2008–2009. Selection of patients was performed by denoting arbitrarily the first day of every other month as the date of interest. Accordingly, we obtained lists of admitted patients in all three departments on that date. Patients under age 65, patients with active malignancy (defined as known metastases or patients receiving chemotherapy), patients on dialysis, and patients who were chronically ventilated were excluded. We also excluded admissions where the patient died within the index admission, elective admissions, admissions with prolonged stay (above 30 days), and patients with "pure" surgical conditions (e.g., aortic dissection) who were admitted to the medical ward [Figure 1].

Patients' data were collected from the discharge letters in the computerized archives of our hospital and the two other major medical centers in Jerusalem (in cases with readmissions to other hospitals). The data were drawn from the first admission of the patient during the selected time frame (index admission). In cases of multiple rehospitalizations, data were drawn from the readmissions within 3 months. Age, gender, residence (home, nursing institution), cognitive state (impaired or intact), major diagnoses as appeared on the discharge letter, number of admissions during the period January 2008 to the end of December 2009, and length of stay were selected as parameters of interest. Specific comorbidities were observed. Those were chosen according to previously published reports [7-14]: congestive heart failure defined as furosemide therapy (≥ 40 mg/day), ischemic heart disease defined as status post-myocardial infarction, status post-therapeutic cardiac catheterization or previous coronary artery bypass graft surgery; diabetes defined as treatment with any anti-diabetic medication; and chronic lung disease, mainly chronic obstructive pulmonary disease or any pulmonary diseases that required home oxygen therapy, systemic corticosteroids or non-invasive ventilation.

Data on laboratory workup were also collected, including creatinine, sodium, albumin and uric acid levels, and previous or current carbapenem-resistant *Klebsiella pneumoniae* carrier state. Glomerular filtration rate was calculated using the four-variable Modification of Diet in Renal Disease formula.

The eligible cohort of patients (n=496) was divided into two groups: patients who were admitted to any medical department but not readmitted within 3 months of discharge during a 2 year follow-up, and those who were readmitted within 3 months at any time point during the selected time frame. Each demographic and medical parameter was assessed in both groups, and factors that were significantly associated with readmission were selected to construct a scoring tool.

A univariate analysis was performed to detect which variables were linked with readmission. Results were considered statistically significant when $P < 0.05$. Regarding continuous variables we constructed receiver operating characteristic curves to determine the cutoffs that were most associated with readmission. A stepwise multivariate logistic regression analysis was performed and potential factors that contributed the most to readmission were considered for further statistical evaluation. Parameters that did not significantly add to the sensitivity of the model were eliminated, and eventually a five-variable scoring tool was suggested. To verify if our derived model could predict readmission, we constructed ROC curves with the predicted probabilities. Sensitivity, specificity, positive predictive value, negative predictive value and odds ratio were calculated for various scores on the readmission evaluation tool. The validity of the scoring tool was later assessed with a cohort of 200 additional patients during 2010. Patients' data were collected as described above. The discriminatory ability of the prediction tool in the derivation and validation groups was quantified through the area under the ROC curve. Analyses were carried out with SPSS version 17.

ROC = receiver operating characteristic

RESULTS

We evaluated data on 930 patients admitted between January 2008 and December 2009. After the exclusions the final analysis included 496 patients [Figure 1]; 58.9% of them (n=292) experienced at least one unplanned readmission within 3 months of discharge.

The most common primary admission diagnoses were pulmonary and urinary tract infections and CHF exacerbations (20.6%, 12.7% and 13.3% respectively) [Table 1]. Urinary tract infection or urosepsis were significantly more common in the readmitted patient group.

Medical and demographic variables of patients are shown in Table 2. The mean age of all patients was 81.1 years (median 82, range 65–99). The readmitted patients were older, median 83 (range 65–96) as compared with 79 (range 65–99) in the non-readmitted patients ($P < 0.001$). The majority of patients who experienced short-term readmission (n=205, 68.8%) were 80 years or older.

Nursing home residence, impaired cognition and CHF were significantly more common in the readmitted patient group [Table 2]. IHD was also more common in that group,

CHF = congestive heart failure
IHD = ischemic heart disease

Figure 1. Preliminary cohort and final study group

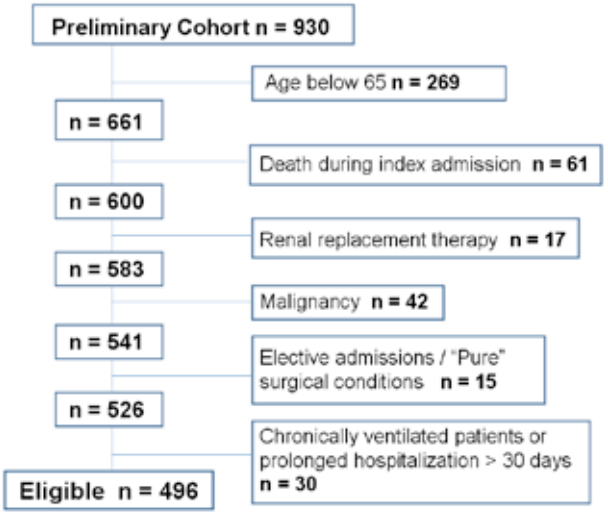

Table 1. Primary diagnoses of admission in the study cohort

Primary diagnoses of admission	All patients (n=496)	Non-readmitted patients (n=204)	Readmitted patients (n=292)	*P* value
Abdominal infection	21 (4.2%)	8 (3.9%)	13 (4.5%)	0.48
Acute renal failure	12 (2.4%)	4 (2%)	8 (2.7%)	0.4
Bronchitis/pneumonia	102 (20.6%)	43 (21.1%)	59 (20.2%)	0.45
Cardiac (MI, arrhythmia, etc.)	43 (8.7%)	18 (8.8%)	25(8.6%)	0.52
Congestive heart failure exacerbation	66 (13.3%)	22 (10.8%)	44 (15.1%)	0.1
Chronic lung disease exacerbation	48 (9.7%)	27 (13.2%)	21 (7.2%)	0.02
Metabolic	13 (2.6%)	5 (2.5%)	8 (2.7%)	0.54
Neurologic (CVA, etc.)	44 (8.9%)	21 (10.3%)	23 (7.9%)	0.219
VTE	4 (0.8%)	2 (1%)	2 (0.7%)	0.54
Sepsis	9 (1.8%)	2 (1%)	7 (2.4%)	0.2
UTI/urosepsis	63 (12.7%)	24(6.9%)	49 (16.8%)	< 0.01
Bone, joint or soft tissue Infection	32 (6.5%)	19 (9.3%)	13 (4.5%)	0.02
Other	39 (7.9%)	19 (9.3%)	20 (6.8%)	0.2

Data were drawn from index admissions
CVA = cerebrovascular accident, MI = myocardial infarction, UTI = urinary tract infection, VTE = venous thromboembolism

Table 2. Demographic and medical variables of participants

	All patients (n=496)	Non-readmitted patients (n=204)	Readmitted patients (n=292)	*P* value
Median age (range)	82 (65–99)	79 (65–99)	83 (65–96)	< 0.001
Male gender	233 (47%)	91 (44.6%)	142 (48.6%)	0.21
Nursing home residence	112 (22.6%)	23 (11.2%)	89 (30%)	< 0.001
Impaired cognition	173 (34.9%)	41 (20%)	132 (45.2%)	< 0.001
CHF	221 (44.6%)	64 (31.3%)	157 (53.8%)	< 0.001
IHD	162 (32.7%)	58 (28.4%)	104 (35.6%)	0.06
Diabetes	183 (36.9%)	69 (33.8%)	114 (39%)	0.14
CLD	120 (24.2%)	49 (24%)	71 (24.3%)	0.51

CHF = congestive heart failure, IHD = ischemic heart disease, CLD = chronic lung disease

with borderline significance. Diabetes was quite prevalent in both groups. Serum creatinine and uric acid levels were significantly higher in the readmitted patient group, while albumin and calculated glomerular filtration rate were significantly lower. The median length of stay in the study population was 7 days (range 1–30) ($P = 0.47$). During the follow-up period, the median number of admissions in the readmitted patients' group was 4 (range 2–17). Seven patients (1.4%) were carriers of CRKP on their index admission and 14 subjects (2.8%) had acquired CRKP during the 2 year follow-up. All of them had unplanned readmissions within 3 months of discharge.

CRKP = carbapenem-resistant *Klebsiella pneumoniae*

Table 3. Clinical and laboratory variables and their association with readmission within 3 months

	Non-readmitted patients (n=202)	Readmitted patients (n=292)	Odds ratio (95% CI)	*P* value
Age ≥ 80	93 (31.2%)	205 (68.8%)	2.8 (1.9–4.0)	< 0.001
Nursing home residence	23 (20.5%)	89 (79.5%)	3.5 (2.1–5.7)	< 0.001
Impaired cognition	41(23.7%)	132 (76.3%)	3.3 (2.2–5)	< 0.001
CHF	64 (29%)	157 (71%)	2.5 (1.8–3.7)	< 0.001
IHD	58 (35.8%)	104 (64.2%)	1.4 (1–2)	0.06
Creatinine › 1.5 mg/dl	37 (27.8%)	96 (72.2%)	2.2 (1.4–3.4)	< 0.001
Sodium ‹ 130 or › 150 mEq/L	14 (24.1%)	44 (75.9%)	2.4 (1.3 – 4.5)	0.003
Albumin ‹ 3 g/dl*	27 (27.3%)	72 (72.7%)	2.3 (1.4 – 3.7)	< 0.001
Uric acid › 8 mg/dl**	12 (24.5%)	37 (75.5%)	3.8 (1.9 – 7.8)	< 0.001

*n = 455, **n = 240
CHF = congestive heart failure, IHD = ischemic heart disease, CI = confidence interval

Eight variables that were strongly associated with readmission ($P < 0.05$) were detected in the univariate analysis [Table 3]. A multivariate analysis was performed and the final model included only five risk factors: age 80 years or older, impaired cognition, nursing home residence, CHF, and creatinine level above 1.5 mg/dl. The presence of each variable was scored as 1. Positive predictive value for readmission was calculated at different cutoffs along with negative predictive value, sensitivity, specificity and odds ratio. A score of 3 or higher had a PPV of 80% (sensitivity 45%, specificity 85%). AUC was 0.745. Lower cutoff scores, i.e., ≥ 2 or ≥ 1 yielded a lower PPV (74.8% and 66%, respectively) yet higher sensitivity rates (78.1% and 94.5%, respectively). According to the model, the PPV was still as high as 20% even if a patient had a score of zero.

During the year 2010, an observational validation study was conducted with a cohort of 200 patients; 45.5% (n=91) were readmitted at least once within 3 months. The mean age of these patients was 81.5 (median 81.5, range 65–98). Fifty-one percent (n=102) were females. Respiratory and urinary tract infections and CHF exacerbations were dominant diagnoses (22.5%, 20% and 14.5% respectively). In this validation group a score of 3 or higher had a PPV of 67% (specificity 78%, sensitivity 52.7%, AUC 0.7). Similarly, lower cutoff scores of ≥ 2 and ≥ 1 yielded a lower PPV (56% and 49%, respectively).

PPV = positive predictive value
AUC = area under the curve

DISCUSSION

In this study we developed a simple scoring tool that would help identify elderly patients at risk of unplanned readmission. The suggested model included five major factors: age 80 or older, any degree of impaired cognition, nursing home residence, CHF, and creatinine level above 1.5 mg/dl. In the derivation cohort, we found that a score ≥ 3 was quite reasonable as a cutoff score, when assessing the risk of readmission within 3 months, with a corresponding PPV of 80% (AUC 0.75). In the validation cohort the calculated PPV was 67% for flagged patients (AUC 0.7).

The P_{ra} (probability of repeated admission) model [15] was able to identify a subgroup of patients at high risk of rehospitalization (41.8% over 4 years) using eight risk factors: older age, male gender, poor self-rated general health, availability of an informal caregiver, IHD, and having had, during the previous year, a hospital admission, more than six doctor visits, or diabetes. However, it was based on a self-reported questionnaire and achieved only fair performance (AUC 0.61). The LACE index [5] and the PARR algorithm [6] achieved a discriminatory power of 0.68 and 0.69 respectively. The former included only cognitively intact patients and patients from both surgical and medical wards, and the latter included 21 parameters, of which many are not available in "real-life" practice. Similarly, models proposed by Coleman et al. [16] and Hasan et al. [17] were too complex.

Regardless of which model one prefers, readmission could not be anticipated in at least one-third of hospitalized patients. There are numerous potential confounding factors that could affect the rate of readmission. Incorporating additional variables may complicate the scoring tool without significantly improving the predictive yield. Old age, impaired cognition, CHF, renal impairment, hyponatremia and hypoalbuminemia were all associated with readmission [Table 3]. The findings are consistent with previously published studies [2,7-13,18-20]. We did not include sodium and albumin levels in our scoring method because they did not contribute to the model's discriminatory power. In the preliminary analysis we found that high levels of uric acid were associated with readmission. This is concordant with recent reports suggesting that uric acid might serve as a surrogate marker of worsening CHF and the metabolic syndrome [21,22]. Including uric acid in the regression analysis did not significantly change the sensitivity or specificity of the model. Likewise, IHD was more prevalent in the readmitted patient group as previously reported [14] but did not add to the model's predictive power and therefore was not included.

In contrast to earlier reports [23], length of stay was not associated with risk of readmission within 3 months. It is possible that in our cohort the duration of admission did not reflect the severity of illness. Sample size could also have affected this finding.

A worrisome finding was the prevalence of CRKP carrier state among the patients. All 21 patients in the cohort who were either CRKP carriers or acquired CRKP during the follow-up period belonged to the readmitted patient group. This is consistent with the notion that severity of illness in CRKP carriers is relatively high and they are therefore prone to readmissions. This has been demonstrated in the case of CRKP bacteremia [24]. This variable was not added to the score scheme due to the small number of CRKP carriers but obviously the risk of rehospitalization in those patients is very high.

Our study has a number of limitations. First, as a retrospective study, our database is limited to the variables that were collected during admission. Second, medical diagnoses of impaired cognition and CHF were not defined by strict criteria. CHF was defined as furosemide therapy ≥ 40 mg/day. In the majority of patients, this implies clinically relevant heart failure without relying on echocardiogram or other measures. The goal of this study was to define a practical scoring tool that would be based on readily available parameters, and therefore we chose not to define medical conditions by the conventional strict criteria. The suggested method is tailored to a real-life state in internal medicine wards. Third, the department of cardiology (a 35 bed ward) is not represented in the study. This could have affected the relative contribution of IHD as a risk factor of readmission. Fourth, a higher rate of readmissions of patients with chronic lung disease was expected, as had been shown before [10,25]. The observed rate could be attributed to the small sample size and the rather old study population. Finally, external validation of the suggested model was not performed; therefore, the use of this tool is limited to a patient population that is comparable to the one in the study.

In summary, we present a practical scoring method that could help identify patients who are prone to readmission within 3 months. Such high risk patients may be allocated to an intervention program that would minimize the rate of readmission and reduce the overall cost of patient care and the burden on internal medicine wards. The strength of this scoring tool, as compared with previously published scores, is its simplicity.

PARR = patients at risk for rehospitalization

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Capsule

Melanomas resist T cell therapy through inflammation-induced reversible dedifferentiation

Adoptive cell transfer therapies (ACTs) with cytotoxic T cells that target melanocytic antigens can achieve remissions in patients with metastatic melanomas, but tumors frequently relapse. Hypotheses explaining the acquired resistance to ACTs include the selection of antigen-deficient tumor cell variants and the induction of T cell tolerance. However, the lack of appropriate experimental melanoma models has so far impeded clear insights into the underlying mechanisms. Landsberg and co-workers established an effective ACT protocol in a genetically engineered mouse melanoma model that recapitulates tumor regression, remission and relapse as seen in patients. They report the unexpected observation that melanomas acquire ACT resistance through an inflammation-induced reversible loss of melanocytic antigens. In serial transplantation experiments, melanoma cells switch between a differentiated and a dedifferentiated phenotype in response to T cell-driven inflammatory stimuli. The authors identified the pro-inflammatory cytokine tumor necrosis factor-alpha (TNFα) as a crucial factor that directly caused reversible dedifferentiation of mouse and human melanoma cells. Tumor cells exposed to TNFα were poorly recognized by T cells specific for melanocytic antigens, whereas recognition by T cells specific for non-melanocytic antigens was unaffected or even increased. Our results demonstrate that the phenotypic plasticity of melanoma cells in an inflammatory microenvironment contributes to tumor relapse after initially successful T cell immunotherapy. On the basis of our work, they propose that future ACT protocols simultaneously target melanocytic and non-melanocytic antigens to ensure broad recognition of both differentiated and dedifferentiated melanoma cells, and include strategies to sustain T cell effector functions by blocking immune-inhibitory mechanisms in the tumor microenvironment.

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Eitan Israeli

"Often the search proves more profitable than the goal"

E. L. Konigsburg (born 1930), American author and illustrator of children's books and young adult fiction