International Orthopaedics (SICOT) (2013) 37:477–482
DOI 10.1007/s00264-012-1763-7

ORIGINAL PAPER

External validation of the discharge of hip fracture patients score

Anne J. H. Vochteloo · Elvira R. Flikweert · Wim E. Tuinebreijer · Andrea B. Maier · Rolf M. Bloem · Peter Pilot · Rob G. H. H. Nelissen

Received: 26 November 2012 / Accepted: 17 December 2012 / Published online: 16 January 2013

Abstract
Purpose This paper reports the external validation of a recently developed instrument, the Discharge of Hip fracture Patients score (DHP) that predicts discharge location on admission in patients living in their own home prior to hip fracture surgery.
Methods The DHP (maximum score 100 points) was applied to 125 hip fracture patients aged 50 or more years admitted to an academic centre in the northern part of the Netherlands (Groningen cohort). The characteristics of this cohort, sensitivity, specificity and positive and negative predictive value (PPV, NPV) of the DHP for discharge to an alternative location (DAL) were calculated and compared with the original cohort of hip fracture patients from the western part of the Netherlands (Delft cohort). Scoring 30 points or higher indicated DAL.
Results The Groningen cohort was younger compared to the Delft cohort, (mean age 75.4 vs. 78.5 years, P=0.005) but was more often classified ASA III/IV (46.4 % vs. 25.2 %, P< 0.001). Sensitivity of the DHP for DAL in the Groningen cohort was 75 % (vs. 83.8 %), specificity of 66.7 % (vs. 64.7 %) and a PPV of 86.3 % (vs. 79.2 %), compared to the Delft cohort.
Conclusion External validation of the DHP was successful; it predicted discharge location of hip fracture patients accurately in another Dutch cohort, the sensitivity for DAL was somewhat lower but the PPV higher. Therefore, the DHP score is a useful valid and easily applied instrument for general hip fracture populations.

A. J. H. Vochteloo (✉) · R. G. H. H. Nelissen
Department of Orthopaedic Surgery,
Leiden University Medical Center,
P.O. Box 9600, 2300 RC, Leiden, The Netherlands
e-mail: ajhvochteloo@hotmail.com

A. J. H. Vochteloo · R. M. Bloem · P. Pilot
Department of Orthopaedic Surgery, Reinier de Graaf Group,
Delft, The Netherlands

E. R. Flikweert
Department of Traumatology,
University Medical Center Groningen,
Groningen, The Netherlands

W. E. Tuinebreijer
Department of Surgery-Traumatology, Erasmus MC,
University Medical Centre Rotterdam,
Rotterdam, The Netherlands

A. B. Maier
Department of Internal Medicine, Section of Gerontology
and Geriatrics, VU University Medical Center,
Amsterdam, The Netherlands

Abbreviations

DHP	Discharge of Hip fracture Patients score
DAL	Discharge to an Alternative Location
ASA	American Society of Anesthesiologists
LOS	Length of Stay
ADL	Activities of Daily Living
SD	Standard Deviation
OR	Odds Ratio
CI	Confidence Interval
ROC	Receiver Operating characteristics Curve
AUC	Area Under the Curve
PPV	Positve Predictive Value
NPV	Negative Predictive Value
IQR	InterQuartile Range

Introduction

Worldwide, numbers of hip fracture patients are growing with associated rises in costs [1, 2]. Discharge to an alternative location (DAL, compared to the pre-fracture residence) or the necessity for arranging additional postoperative care at home for those that can go home directly after discharge can contribute to a longer stay in hospital and contributes to additional health care costs, which may be preventable [3, 4]. Early planning of the date and the type of discharge location may thus be a powerful tool in reducing costs [4–6].

Recently, we described the Discharge of Hip fracture Patients score (DHP) [7]. This score predicts, on admission, the discharge location in patients living in their own home prior to admission for a hip fracture. The DHP was designed on prospective data of a Dutch cohort of 310 patients aged 50 or more years admitted to a general teaching hospital in the western part of the Netherlands [7]. Risk factors for DAL were identified using multivariable regression analysis [7]. Higher age, female gender, dementia, absence of a partner and a limited level of mobility were found to be predictive. These risk factors were used as score items, each with a weighing factor, based upon the beta coefficient.

In this paper we present the results of external validation of the DHP in another Dutch cohort of hip fracture patients.

Methods

Patients

The DHP was developed using data of 310 hip fracture patients aged 50 years and older admitted to a 450-bed teaching hospital (Delft, the Netherlands) between January 2008 and December 2009 [7]. Patients with a fracture due to a high-energy trauma or with a pathological fracture, patients not living in their own home prior to admission, those treated conservatively and those that died during hospital stay were not included in this cohort. This cohort will be referred to as the 'Delft cohort'.

The DHP was externally validated in a cohort of 125 hip fracture patients admitted to a university hospital (Groningen, the Netherlands) between January 2010 and June 2011. The same inclusion and exclusion criteria were applied to this cohort. This cohort will be referred to as the 'Groningen cohort'.

Data collection

Uniform collection and recording of data of all patients of both cohorts was achieved by standard evaluation on admission, according to the local standardised care for hip fracture patients.

Collected demographic data included age, gender, presence of a partner and discharge location.

Characteristics obtained on admission were American Society of Anesthesiologists (ASA) Physical Status classification, presence of dementia based upon history taking from patients, families and carers, presence of anaemia on admission based on the criteria of the World Health Organisation (haemoglobin level below 7.5 mmol/L (12 g/dL) in women and below 8.1 mmol/L (13 g/dL in men), level of mobility, type of fracture (intra- or extracapsular hip fracture) and length of stay (LOS) [8, 9].

Pre-fracture level of mobility

The level of mobility was divided into four main categories; mobile without the use of an aid in- and outdoors, mobile in- and outdoors with the use of an aid in- and/or outdoors, only mobile indoors (regardless the use of an aid) and the last group was immobile both in- and outdoors. A cane, crutch(es) or walker were all considered an aid, patients in a wheelchair were considered to be immobile.

Discharge of hip fracture patients score (DHP)

The DHP score ranged from zero to 100 points. Higher age, female gender, dementia, absence of a partner, and a more limited level of mobility are score items, each with a weighting factor based upon the beta coefficient in the multivariable regression analysis. The beta coefficients were rounded up and the regression coefficients associated with the questions were transformed into a simple score that could be summated up to obtain an aggregate score (Table 1) [7].

With ROC analysis, the cut-off point of 30 was calculated. Scoring 30 points or more predicted discharge to an alternative location in the Delft cohort with a sensitivity of 83.8 %, a specificity of 64.7%a negative

Table 1 Discharge of Hip fracture Patients score (DHP)

Predisposing risk factors for discharge to an alternative location	Points
Age	
* 50–64.9 years	0
* 65–79.9 years	10
* ≥80 years	20
Female gender	10
Dementia	20
Absence of a partner	10
Mobility at admission	
Mobile in- and outside without an aid	0
Mobile in- and outside with an aid for either one or for both	10
Only mobile indoors	40
Immobile	40
Total score	

predictive value of 71.3 % and a positive predictive value of 79.2 % [7].

Statistical analysis

Demographic continuous data are presented as means, with standard deviations (SD or median with the interquartile range (IQR) in case of a non-normal distribution). Categorical data are presented as the number of subjects in the category, along with the percentages. Baseline characteristics of both cohorts were compared, using the Student's T-test. Sensitivity, specificity, positive and negative predictive value (PPV and NPV) for DAL and the positive and negative likelihood ratio were calculated for the Groningen cohort and compared to the Delft cohort.

A receiver operating characteristics curve (ROC) was created by plotting the sensitivity (true positive rate) versus the 1-specificity (false positive rate). The actual area under the curve (AUC) measures the ability of the instrument to classify correctly DAL.

P-values lower than 0.05 were considered statistically significant. All data were analysed in IBM SPSS Statistics 19.0 (SPSS Inc. Chicago, USA).

Results

Patients

Table 2 shows clinical characteristics of the Delft and Groningen cohorts, stratified by discharge location. The mean (SD) age of the Delft patients was 78.5 (10.5) years, 67.1 % were female. One hundred and ninety-one (61.7 %) patients were discharged from hospital to an alternative location. The mean (SD) age of the Groningen patients was 75.4 (9.2) years, 69.6 % was female. Ninety-two (73.6 %) patients were discharged to an alternative location from hospital in the Groningen cohort.

In both cohorts, patients discharged to an alternative location were older, more often classified ASA III/VI and had a longer LOS compared to those who were discharged directly to their own home. In the Delft cohort, they were also more often female and suffered more from dementia.

Some baseline parameters of both cohorts were significantly different: Patients of the Groningen cohort were younger (P=0,002), more often classified ASA III/IV (P< 0,001) and had a better level of mobility (more patients walked without an aid, P=0.01). Furthermore, more patients

Table 2 Clinical characteristics of the Groningen and Delft cohort and stratified by discharge location

	Groningen	Discharge location		*P*-value[a]	Delft	Discharge location		*P*-value[a]
	All patients *n*=125	Own home *n*=33	Alternative location *n*=92		All patients *n*=310	Own home *n*=119	Alternative location *n*=191	
Age category				<0.001				<0.001
50–64.9 years old	19 (15.2)	10 (30.3)	9 (9.8)		45 (14.5)	36 (30.3)	9 (4.7)	
65–79.9 years old	64 (51.2)	20 (60.6)	44 (47.8)		107 (34.5)	54 (45.4)	53 (27.7)	
≥80 years old	42 (33.6)	3 (9.1)	39 (42.4)		158 (51.0)	29 (24.4)	129 (67.5)	
Female gender	87 (69.6)	21 (63.6)	66 (71.7)	0.385	208 (67.1)	63 (52.9)	145 (75.9)	<0.001
No partner at admission	60 (48.0)	12 (36.4)	48 (52.2)	0.119	174 (56.1)	44 (37.0)	130 (68.1)	<0.001
ASA classification III/IV	58 (46.4)	7 (21.2)	51 (55.4)	0.001	78 (25.2)	20 (16.8)	58 (30.4)	0.007
Dementia	9 (7.2)	0 (0.0)	9 (9.8)	0.111	29 (9.4)	28 (14.7)	1 (0.8)	<0.001
Anaemia at admission	39 (31.2)	6 (18.2)	33 (35.9)	0.060	100 (32.3)	28 (23.5)	72 (37.7)	0.009
Pre-fracture mobility				<0.001				<0.001
Without an aid	82 (65.6)	30 (90.9)	52 (56.5)		164 (52.9)	92 (77.3)	72 (37.7)	
With an aid	43 (34.4)	3 (9.1)	40 (43.5)		127 (41.0)	26 (21.8)	101 (52.9)	
Only mobile indoors	0 (0)	0 (0.0)	0 (0.0)		16 (5.2)	0 (0.0)	16 (8.4)	
Immobile	0 (0)	0 (0.0)	0 (0.0)		3 (1.0)	1 (0.8)	2 (1.0)	
Intracapsular hip fracture	71 (56.8)	23 (69.7)	48 (52.2)	0.081	192 (61.9)	87 (73.1)	105 (55.0)	0.001
Osteosynthesis	84 (67.2)	24 (72.7)	60 (65.2)	0.431	195 (62.9)	88 (73.9)	107 (56.0)	0.001
Median LOS, days (IQR)	7 (4)	6 (4)	8 (6)	<0.001[b]	9 (7)	7 (5)	12 (9)	<0.001[b]

Values are given as number (percentage) if not defined otherwise

LOS length of stay, *ASA* American Society of Anesthesiologists Physical Status classification, *IQR* interquartile range

[a] Bivariate analysis

[b] Nonparametric analysis

Table 3 Results of the validity analysis of the DHP for discharge to an alternative location, for the cut-off point of 30 and higher (out of 100) in the Groningen and Delft cohort

	Groningen cohort		Delft cohort	
		95 % CI		95 % CI
Sensitivity	75.0	64.9–83.5	83.8	77.8–88.7
Specificity	66.7	48.2–82.0	64.7	55.4–73.2
Positive Predictive Value	86.3	76.7–92.9	79.2	72.8–84.4
Negative Predictive Value	48.9	33.7–64.2	71.3	61.7–79.4
Likelihood ratio Positive (Sens/1-Spec)	2.25	1.37–3.7	2.37	2.0–2.7
Likelihood ratio Negative (1-Sens/Spec)	0.38	0.24–0.58	0.25	0.20–0.40
Correlation with discharge to alternative location	0.38	n/a	0.50	n/a

CI: Confidence Interval, all values are percentage if not defined otherwise

were discharged to an alternative location in the Groningen cohort compared to the Delft cohort (P=0.02).

Validation of the DHP

The DHP was applied to the Groningen cohort; the results are displayed in Table 3.

Compared to the values in the Delft cohort, the PPV was higher (86.3 vs. 79.2 %), but the sensitivity (75 vs. 83.8 %) and the NPV for the score in the Groningen cohort were lower (48.9 vs. 71.3 %).

Figure 1a shows the ROC curve of the DHP in the Groningen cohort, the AUC was 0.75 (95 % CI 0.66–0.82), Fig. 1b demonstrates the Delft ROC curve with an AUC of 0.84 (95 % CI 0.79–0.88).

Discussion

The goal of this study was the external validation of the DHP. This score has recently been developed in a cohort of Dutch hip fracture patients in Delft showing a good sensitivity and a reasonable PPV and was easy to use due to readily obtainable data on admission [7].

By providing early reliable prediction of discharge location, the DHP can be used to facilitate the work of the health care professionals, e.g., liaison officers to make early arrangements for discharge, thus potentially reducing LOS substantially [4–7]. Since population density, hospital and rehabilitation potentials are different between the areas in The Netherlands, testing for external validity of a score is a necessity in order to judge its applicability in general. When performing an external validation, it is of importance to realise two issues. Firstly, appreciation of the important characteristics of the score (i.e., sensitivity vs. specificity and PPV vs. NPV), secondly, that external validation often results in lower scores in the second cohort compared to the first cohort, since the two cohorts are never exactly the same. The latter only underscores the necessity for validation before general application.

For example, external validation of a questionnaire for chronic obstructive pulmonary disease patients showed poorer

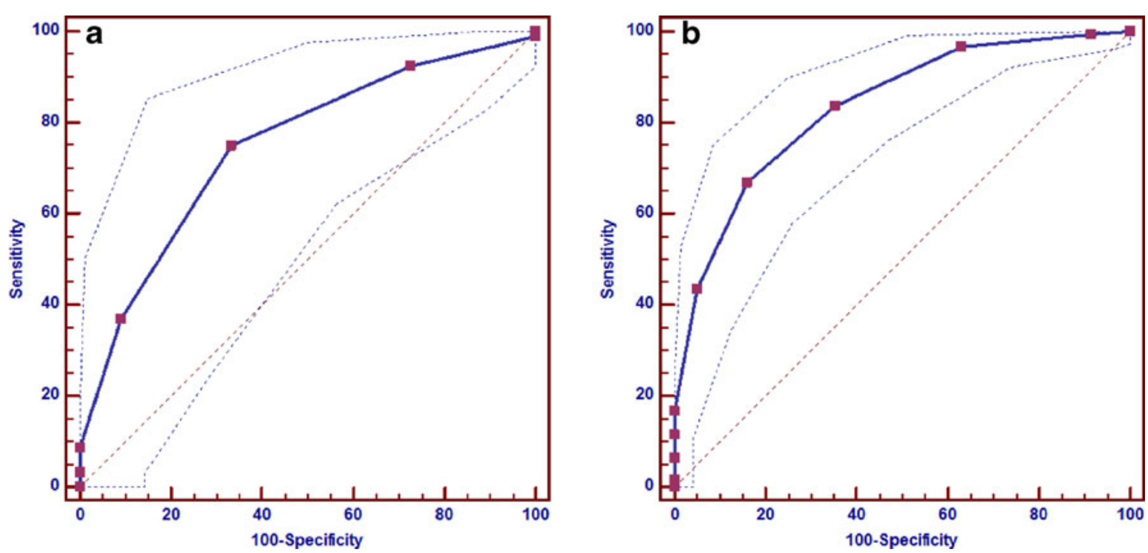

Fig. 1 ROC curves of the DHP with 95 % confidence intervals in the Groningen (**a**) and Delft (**b**) cohorts. The diagonal indicate results no better than by chance

discriminating ability (i.e., a smaller AUC) between normal and affected patients compared to the primary internal validation [10]. This was also the case in our study: a smaller AUC with a wider 95 % CI. The wider 95 % CI in the Groningen cohort could be attributed to the smaller sample size in this cohort (125 versus 310 patients) but also to confounders for discharge to an alternate location such as a different discharge policy, more potential for day care help at home and rehabilitation centres near the hospital.

We consider a good sensitivity and high PPV to be the most important features of the score. Sensitivity is the ability of a test to give positive results in true cases and the PPV the percentage of true positives of all positive scoring patients. In this study a positive result is a score of 30 or more points and true positive is a patient scoring 30 and higher on admission who is discharged to an alternative location. In contrast, specificity is the ability of a test to give negative results in negative cases, the NPV is the percentage of true negatives of all negative scoring patients: In this study a negative result is a score under 30 points and true negative is a patient scoring less than 30 who is discharged directly to their own home from hospital. In daily practice it is of greater importance and impact for both patient and health professionals, e.g., liaison officers to know whether a patient will be discharged to an alternative location. Therefore, a better sensitivity and a higher PPV are the most important features of the score. The PPV in the Groningen cohort was higher compared to the Delft cohort, the NPV was lower. The lower NPV is explained by the fact that predictivity and prevalences are not comparable across groups because they depend on the prevalence of the outcome (in our case discharge to an alternative location, DAL). The prevalence of DAL in the Groningen cohort was higher (74 % versus 62 %), resulting in a lower chance of discharge directly to the own home, corresponding with the NPV. Finally, the differences in all characteristics of the score can also be explained by the fact that there are factors of influence that were not risk items in the DHP but that do influence the place of discharge.

We demonstrated in the previous paper on the DHP that the Delft cohort was representative for a general hip fracture population in Europe with regards to characteristics including age, distribution of type of fracture and gender and the number of patients living in their own home prior to sustaining a hip fracture [7]. The Groningen cohort was comparable to the Delft cohort, other than age, poorer general condition (ASA III/IV) and a higher level of mobility. The latter is directly related to the lower mean age, as we demonstrated previously [11]. The higher ASA scores despite younger age might be due to the fact that it was a cohort from a university hospital, often having more co-morbidities. Furthermore, significantly more patients were discharged to an alternative location in the Groningen cohort compared to the Delft cohort, after a longer LOS. The LOS might have been longer due to the poorer general condition. The higher percentage of DAL can partially be explained by the longer LOS, often due to a more complicated postoperative course [4, 12–14]. Another reason is the difference in local discharge policy. The Groningen cohort was more easily discharged to a nursing home compared to the Delft cohort. These differences are good for external validation; if a score is valid in a population that is somewhat different from the original population, the score might be even of higher value than if it would only work in exactly the same type of cohort.

Limitations

Although the DHP is externally validated and the score was easily applicable to the Groningen cohort as well, it has its limitations. First: absence of more detailed data of cognitive function, combining the mobility categories "immobile" and "only mobile indoors" to one group due to the small number of patients who were immobile and the fact that it might not be applicable to other countries than the Netherlands with its own typical private health care organisation [7]. However, the score items used were comparable to those in previous models from other countries, both with national health care as well as private health care systems (UK, Sweden, US) [15–18]. The limitations of this validation study are the smaller AUC of the DHP in the Groningen cohort and the relatively small sample size, resulting in a wider 95 % CI of the AUC.

Conclusions

The external validity of the DHP for hip fracture patients is good in the Dutch health care setting, validated with an acceptable sensitivity and a good PPV. Therewith its use in other hip fracture cohorts is recommended. However, before extrapolating our Dutch results to another country, the score should preferably be validated in that specific country.

Acknowledgments The work was supported by the Netherlands Organisation for scientific research (NGI/NWO; 05040202 and 050-060-810 Netherlands Consortium for Healthy Aging (NCHA)) and the seventh framework program MYOAGE (HEALTH-2007-2.4.5-10) and Reumafonds LRR.

No competing interests declared.

References

1. Cooper C, Campion G, Melton LJ (1992) Hip fractures in the elderly: a world-wide projection. Osteoporos Int 2:285–289
2. Cumming RG, Nevitt MC, Cummings SR (1997) Epidemiology of hip fractures. Epidemiol Rev 19:244–257

3. Haentjens P, Autier P, Barette M, Boonen S (2001) The economic cost of hip fractures among elderly women. A one-year, prospective, observational cohort study with matched-pair analysis. Belgian Hip Fracture Study Group. J Bone Joint Surg Am 83-A:493–500
4. Sahota O, Morgan N, Moran CG (2011) The direct cost of acute hip fracture care in care home residents in the UK. Osteoporos Int 23:917–920
5. O'Cathain A (1994) Evaluation of a hospital at home scheme for the early discharge of patients with fractured neck of femur. J Public Health Med 16:205–210
6. Parker MJ, Pryor GA, Myles JW (1991) Early discharge after hip fracture. Prospective 3-year study of 645 patients. Acta Orthop Scand 62:563–566
7. Vochteloo AJH, Tuinebreijer WE, Maier AB, Nelissen RGHH, Bloem RM, Pilot P (2012) Predicting discharge location of hip fracture patients; the new discharge of hip fracture patients score. Int Orthop 36:1709–1714
8. Nutritional anaemias. Report of a WHO scientific group. (1968) World Health Organ Tech Rep Ser 405:5–37
9. Owens W, Felts J (1978) ASA physical status classifications: a study of consistency of ratings. Anesthesiology 49:239–243
10. Kotz D, Nelemans P, van Schayck CP, Wesseling GJ (2008) External validation of a COPD diagnostic questionnaire. Eur Respir J 31:298–303
11. Vochteloo AJ, Moerman S, Tuinebreijer WE, Maier AB, de Vries MR, Bloem RM et al (2012) More than half of hip fracture patients do not regain mobility in the first postoperative year. Geriatr Gerontol Int, Jun 21. [Epub ahead of print]
12. Haentjens P, Lamraski G, Boonen S (2005) Costs and consequences of hip fracture occurrence in old age: an economic perspective. Disabil Rehabil 27:1129–1141
13. Merchant RA, Lui KL, Ismail NH, Wong HP, Sitoh YY (2005) The relationship between postoperative complications and outcomes after hip fracture surgery. Ann Acad Med Singapore 34:163–168
14. Foss NB, Palm H, Krasheninnikoff M, Kehlet H, Gebuhr P (2007) Impact of surgical complications on length of stay after hip fracture surgery. Injury 38:780–784
15. Keene J, Anderson C (1982) Hip fractures in the elderly. Discharge predictions with a functional rating scale. JAMA 248:564–567
16. Thorngren KG, Ceder L, Svensson K (1993) Predicting results of rehabilitation after hip fracture. A ten-year follow-up study. Clin Orthop Relat Res 287:76–78
17. Hashmi M, Tellisi N, Rigby A, Wahab K (2004) The value of a prognostic scoring system in the rehabilitation of elderly patients with proximal femoral fractures. Int J Clin Pract 58:2–5
18. Berglund-Rödén M, Swierstra BA, Wingstrand H, Thorngren KG (1994) Prospective comparison of hip fracture treatment: 856 cases followed for 4 months in The Netherlands and Sweden. Acta Orthop 65:287–294