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# Incidence, complications and risk factors for severe falls in patients on maintenance haemodialysis

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**Abstract**

**Background.** Falls have been insufficiently studied in patients on maintenance haemodialysis (MHD). This study assessed the incidence and complications of severe falls and the ability of risk factors, including the Performance-Oriented Mobility Assessment (POMA) test, to predict them in this population.

**Methods.** All patients on MHD from our centre were asked to participate in this survey. POMA test and a record of risk factors for falls were obtained at baseline. Severe falls, as defined by an admission in an emergency ward, were documented prospectively.

**Results.** Eighty-four patients (median age 69.5 years, minimum 26 years, maximum 85 years) were enrolled. Predialytic POMA scores were low (median 20, minimum 5, maximum 26). After a mean follow-up of 20.6 months (142.2 patient-years), 31 severe falls were recorded in 24 patients (28.6%; incidence 0.22 per patient-year) and complicated by fractures in 54.8% of severe falls. In univariate analysis, age, a past history of falls, malnutrition, depression, but not POMA score, were associated with severe falls. A POMA score of >21 had a negative predictive value of 82%.

**Conclusions.** Severe falls were common in MHD patients in this study and resulted in fractures in >50% of the cases. They were associated with ageing, a past history of falls, malnutrition and depression. Although there was a trend towards a lower POMA score in fallers as compared to non-fallers, the POMA score was not an independent predictor of severe falls in this study. These data may help to stratify the patient's risk of falling in order to target programmes to prevent falls in this population.

**Keywords:** elderly; haemodialysis; POMA test; risk factor

## Introduction

In the general population, the incidence of falls and its risk factors have been thoroughly studied [1–6]. The main risk factor is high age, followed by a past history of falls, weakness of lower extremities, cognitive impairment, psychotropic drug use and history of stroke. Falls are associated with significant morbidity and mortality in elderly patients [4] and an increased likelihood of home placement [7].

Patients on maintenance haemodialysis (MHD) present many of the above-mentioned risk factors. Firstly, the mean age of MHD patients is high and has increased in recent years [8]. Secondly, malnutrition, muscle wasting, depression and the use of psychotropic drugs are highly prevalent in this population [9, 10]. Thirdly, the aggressive volume and blood pressure changes during haemodialysis (HD) sessions and the unique features of renal bone disease are likely to be specific additional risk factors for falls and/or their consequences in this population [10, 11].

Surprisingly, only few studies have examined the prevalence and complications of falls in the MHD population and the predictive value of known risk factors [10, 11]. Knowledge of specific risk factors in this population is essential in order to identify 'high-risk' patients and to develop specific prevention programmes [12]. In the elderly non-dialysed population, the Performance-Oriented Mobility Assessment (POMA test) is an easily reproducible [13, 14] clinical tool for balance and walking assessment, capable of predicting the risk of falls by evaluating the position changes and gait manoeuvres used during normal daily activities (Figure 1). This test requires no equipment and little experience so that it can be used clinically without intensive training or a special setting [15]. In the original test, the maximum score is 28 points; in the elderly community-dwelling population, the mean score is 22.8 [16], whereas in the elderly institutionalized residents, the mean score is around 19.7 [17]. No studies have evaluated the role of the POMA test to estimate the risk of falls in patients on MHD.

The aim of our study was to assess the incidence and the clinical consequences of falls in the MHD population. In addition, we tested the ability of a range of risk factors, including the POMA test, to predict falls in this population.

## Materials and methods

Between June 2005 and July 2008, all prevalent patients on MHD plus incident patients treated in our centre were asked to participate. This corresponded to the entire MHD population of our centre. Patients were included in the study if they met all the following inclusion criteria: age >18 years old, dialysis vintage of >1 month, ability to perform the POMA test and agreement of the patient to participate in the study. The only exclusion criterion was the inability to perform the POMA test due to the impossibility of walking, with or without medical aids.

After oral consent, the participants underwent a baseline evaluation of demographic data and classical risk factors for falls. This evaluation

| Task | Description of balance | Score |
|---|---|---|
| **1. Sitting Balance** | Leans or slides in chair | 0 |
| | Steady, safe | 1 |
| **2. Arises** | Unable without help | 0 |
| | Able, uses arms to help | 1 |
| | Able without using arms | 2 |
| **3. Attempts to Arise** | Unable without help | 0 |
| | Able, requires > 1 attempt | 1 |
| | Able to rise, 1 attempt | 2 |
| **4. Immediate Standing Balance** (first 5 seconds) | Unsteady (swaggers, moves feet, trunk sway) | 0 |
| | Steady but uses walker or other support | 1 |
| | Steady without walker or other support | 2 |
| **5. Standing Balance** | Unsteady | 0 |
| | Steady but wide stance (medial heals > 4 inches apart) and uses cane or other support | 1 |
| | Narrow stance without support | 2 |
| **6. Nudged** (subject at maximum position with feet as close together as possible, examiner pushes lightly on subject's sternum with palm of hand 3 times) | Begins to fall | 0 |
| | Staggers, grabs, catches self | 1 |
| | Steady | 2 |
| **7. Eyes Closed** (at maximum position of item 6) | Unsteady | 0 |
| | Steady | 1 |
| **8. Turing 360 Degrees** | Discontinuous steps | 0 |
| | Continuous steps | 1 |
| **9. Sitting Down** | Unsafe (misjudged distance, falls into chair) | 0 |
| | Uses arms or not a smooth motion | 1 |
| | Safe, smooth motion | 2 |
| **Balance score** | | **___ / 15** |
| **Task** | **Description of Gait** | **Score** |
| **10. Initiation of Gait** (immediately after told to "go") | Any hesitancy or multiple attempts to start | 1 |
| | No hesitancy | 0 |
| **11. Step Length and Height** | Right swing foot does not pass left stance foot with step | 0 |
| | Passes left stance foot | 1 |
| | Right foot does not clear floor completely with step | 0 |
| | Right foot completely clears floor | 1 |
| | Left swing foot does not pass right stance foot with step | 0 |
| | Passes right stance foot | 1 |
| | Left foot does not clear floor completely with step | 0 |
| | Left foot completely clears floor | 1 |
| **12. Step Symmetry** | Right and left step length not equal (estimate) | 0 |
| | Right and left step length appear equal | 1 |
| **13. Step Continuity** | Stopping or discontinuity between steps | 0 |
| | Steps appear continuous | 1 |
| **14. Path** (estimated in relation to floor tiles, 12-inch diameter; observe excursion of 1 foot over about 10 ft. of the course) | Deviation or uses walking aid | 0 |
| | Straight without walking aid | 1 |
| **15. Trunk** | Marked sway or uses walking aid | 0 |
| | No sway but flexion of knees or back or spreads arms out while walking | 1 |
| | No sway, no flexion, no use of arms, and no use of walking aid | 2 |
| **16. Walking Stance** | Heels apart | 0 |
| | Heels almost touching while walking | 1 |
| **Gait score** | | **___ / 11** |
| **TOTAL SCORE** | | **___ / 26** |

**Fig. 1.** The POMA test.

included age, sex, history of fall during the past year, presence of diabetes, polyneuropathy, cerebrovascular accident (CVA) history, depression, dementia, amputation of lower limb, malnutrition, impairment of visual acuity and haemoglobin value. Depression was diagnosed by a qualified psychiatrist, who was independent of the study team, based on DSM-IV criteria. Malnutrition was defined as an unintended weight loss of at least 5% in the last 3 months and/or signs of malnutrition according to the European Best Practice Guidelines on nutrition in dialysed patients [18]. The diagnosis of dementia was based on patient records if available before the onset of MHD and diagnosed by an independent neuropsychologist in our hospital in the case of onset after the start of MHD. Impaired vision was assessed through an ophthalmologic examination performed by an independent ophthalmologist.

An adapted POMA test including nine items for balance and seven for walking (maximal score of 26) was performed immediately, i.e. within 5 min, before an HD session. Unlike the original POMA test with 28 items, the test we used was slightly simplified and counted only 26 items as outlined in the Figure 1. The assessment of walking stability at a rotation of 360° was deleted and the evaluation of the straightness of gait was in fact simplified in order to reduce the test subjectivity. Amputees could be included in the study if they were able to walk using prosthesis and/or crutches and were tested while using these aids. Wheelchair-bound patients but able to walk with the use of prosthesis and/or crutches or other medical helping aid were tested accordingly. An unselected subgroup of 12 patients also underwent a POMA test immediately after the same dialysis session. This subgroup was representative of the whole population studied regarding age, co morbidities, blood pressure measurements, predialysis POMA score and the proportion of former falls (data not shown). All POMA tests were performed by the same health care professional, a registered nurse in our dialysis centre (Dores Hannane). This nurse was

trained and supervised by an experienced physiotherapist before the start of the study and the physiotherapist remained available for advice throughout the study period. The test was usually performed within 12–15 min upon arrival and such a short duration did not have a significant impact neither on the individual patient's dialysis schedule nor on the planning of the dialysis staff. An internal validation of the POMA test showed that the intraindividual variability of the score was very low with a mean coefficient of variation of 0.88%. The patients did not get any education on fall prevention before and during the course of this study.

After the baseline evaluation, the patients were followed prospectively until the end of the study period (July 2008) or until transplantation, death or transfer to another dialysis unit.

A fall was defined as an event that resulted in a person coming to rest inadvertently on the ground or other lower level [19]. The primary end point of this study was the occurrence of a severe fall, defined as a fall requiring presentation to an emergency department and/or hospitalization [11]. Hence, severe falls were actively recorded throughout the whole study period on the basis of visits to the emergency departments of the reference hospital or nearby affiliated hospitals. These visits automatically produced documentation in the patients' flow charts which was easy to be traced. We only collected severe falls, instead of all falls, in order to prevent recall bias and data omission, regarding the high prevalence of dementia and/or cognitive impairment in our study population. Similarly, the information 'prior history of falls', collected at baseline as a known risk factor for incident falls, was also intended as 'history of severe falls' for the same reasons. Secondary end points included the location of the fall (home, public road, dialysis centre, hospital), the timing of the fall relative to the dialysis session (before or after the session or during a day without dialysis) and the complications of the fall (wound, fracture, hospitalization, death). All Fractures were confirmed in the emergency department using X-ray imaging. Monitoring also included pre- and post-dialysis blood pressure values recorded at the last HD session before the fall.

### *Statistical analysis*

Data were presented as percentages for discrete variables and as median (range) for continuous variables. Differences in variables were tested using Student's *t*-test for continuous variables and $\chi^2$ test for categorical variables. Univariate relationships between severe falls occurring within 1 year after baseline and well-established risk factors for falls in the general population, i.e. age, history of fall during the past year, presence of diabetes, polyneuropathy, CVA history, depression, dementia, amputation of lower limbs, malnutrition, impairment of visual acuity, haemoglobin value and the POMA score were examined using logistic regression analysis. The univariate analysis did not include patients with falls occurring >1 year after the POMA test or with incomplete follow-up data at 1 year. In order to prevent erroneous 'overadjustment' of the results, multivariate analysis was not displayed since, for statistical reasons, the number of events, i.e. severe falls within 1 year, was not high enough to perform this analysis. The proportion of patients free of falls overtime was estimated by means of the Kaplan–Meier method. Follow-up was stopped at the moment of transplantation or death; the Kaplan–Meier analysis was censored for death or transplantation.

Analyses were performed using STATA 10.1. All P-values were two sided and values $<0.05$ were considered significant.

## Results

A total of 85 patients were approached, and 84 agreed to participate (median age 69.5 years, minimum 26 years, maximum 85 years; 30 patients $\geq$75 years). Thirty-three percent were females and 38.1% were diabetics. The median dialysis vintage was 1.8 years (0.1–31.3 years). The main primary causes of kidney disease were hypertension (29.8%), diabetes (29.8%) and glomerulonephritis (13.1%). Peripheral vascular disease was present in 19%. These patients were subjected to a total of 96 POMA tests.

Predialytic POMA scores were low (median 20, 5–26). After a mean follow-up of 20.6 months (corresponding to 142.2 patient-years), 31 severe falls occurred in 24 patients (28.6% of patients), 1 patient fell twice and 2 patients four times, resulting in an incidence of 0.22 per patient-year; 17 severe falls were complicated by fractures (54.8% of falls). Hip fracture was the most common fracture (35.3% of fractures), followed by fractures of the pelvis (17.7%) and ribs (11.8%). One severe fall led to a later death. Follow-up was prematurely stopped in 25 patients because of death due to other causes ($n = 19$), transplantation ($n = 3$) or transfer to another dialysis unit ($n = 3$). Severe falls occurred in 54.2% of cases at home, in 16.2% in the dialysis centre, in 12.9% on the public road, in 12.9% during hospitalization and in 3.2%, the location of the fall was unknown. Nine of 24 'fallers' (37.5%) fell within 24 h after the last HD session. Differences in

**Table 1.** Baseline characteristics[a] of non fallers versus fallers

| | Group no falls ($n = 60$) | Group falls ($n = 24$) | P-value |
|---|---|---|---|
| Age, years (range) | 64 (26–85) | 77 (49–85) | 0.0005[b] |
| Female sex, *n* (%) | 17 (28.3) | 11 (45.8) | 0.1[c] |
| Diabetes, *n* (%) | 26 (43.3) | 6 (25) | 0.12[c] |
| Dementia, *n* (%) | 6 (10) | 4 (16.7) | 0.39[c] |
| Depression, *n* (%) | 11 (18.3) | 9 (37.5) | 0.06[c] |
| Amputation, *n* (%) | 7 (11.7) | 1 (4.2) | 0.29[c] |
| CVA (%) | 24 (40) | 9 (37.5) | 0.37[c] |
| Former fall (%) | 10 (17.9) | 9 (45) | 0.02[c] |
| Systolic blood pressure (mmHg)[d] | 146 (98–203) | 143 (102–201) | 0.72[b] |
| Diastolic blood pressure (mmHg)[d] | 73 (40–112) | 70 (52–111) | 0.48[b] |
| Malnutrition, *n* (%) | 23 (38.3) | 14 (58.3) | 0.10[c] |
| Diminished vision, *n* (%) | 24 (40) | 9 (37.5) | 1.0[c] |
| Polyneuropathy, *n* (%) | 23 (38.3) | 11 (45.8) | 0.53[c] |
| Haemoglobin (g/dL) | 120 (87–153) | 121 (88–137) | 0.99[b] |
| POMA test score (range) | 21.5 (6–26) | 19.5 (5–26) | 0.008 |

[a]Values are expressed as median (minimum–maximum) or as *n* (%).
[b]*t*-test (two sided).
[c]Chi-square test.
[d]Systolic and diastolic blood pressure as recorded just before the HD session.

patients who fell and those who did not fall are reported in Table 1. Among fallers, 92% were >65 years and 62.5% were >75 years. In the whole population of this study, the annual mortality was 13.3%. The annual mortality in the year post fall was significantly higher in fallers than in non-fallers (24 versus 11.5%, P: 0.039).

In a subgroup of 12 unselected patients, POMA testing was performed before and after a dialysis session; median POMA test scores were 21 (13–26) and 15 (12–25), respectively, ($P < 0.05$).

To assess the sensitivity and specificity for the POMA test to predict a subsequent severe fall, a wide range of different cut-off values was examined. The highest ratio 'sensitivity (70.8%)–specificity (53.3%)' was obtained at a cut-off value of 21. Among 45 patients with a score <21, 37.8% fell, versus only 17.9% for a score ≥21 ($P = 0.038$). At this value, the negative predictive value was 82.1% and the positive predictive value was 37.8%.

Fifty-five patients had completed follow-up data up to 1 year after baseline. In the univariate logistic analysis of this group, age, depression, malnutrition and a history of falls were associated with severe falls, whereas the POMA score was not (Table 2). In order to illustrate the respective sensitivity/specificity of these risk factors to predict a fall in a given patient in 1 year, we generated a receiver operating charasteristic curve including the above identified four risk factors and another curve including these factors plus the POMA (Figure 2). The addition of the POMA test did not significantly improve the area under the curve, although it appeared additive to the other factors (0.72 versus 0.76, respectively; chi-square 0.33; $P = 0.56$).

**Table 2.** Univariate logistic regression analysis of falls after 1 year of follow-up, according to different baseline characteristics

| Variable | Odds ratio (95% CI) | P-value |
|---|---|---|
| Age (per year) | 1.13 (1.03–1.3) | 0.009* |
| Sex (male versus female) | 0.4 (0.11–1.4) | 0.14 |
| Diabetes (yes versus no) | 1.7 (0.49–5.9) | 0.41 |
| Depression (yes versus no) | 7.6 (1.8–32.6) | 0.006* |
| CVA (yes versus no) | 1.5 (0.4–5.3) | 0.6 |
| Dementia (yes versus no) | 3.7 (0.95–14.1) | 0.06 |
| Malnutrition (yes versus no) | 8.4 (1.7–42.4) | 0.01* |
| POMA score | 0.95 (0.87–1.03) | 0.21 |
| Former fall (yes versus no) | 4.9 (1.2–19.4) | 0.02* |

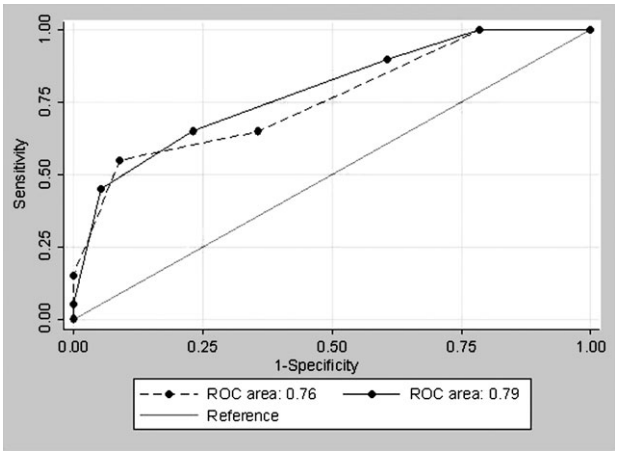


**Fig. 2.** Receiver operating charasteristic (ROC) curve for the event 'severe falls in 1 year' analysed for the identified risk factors, i.e. age, depression, malnutrition and history of falls, with and without the POMA test. The dashed line represents the ROC curve for four combined risk factors without the POMA test. The solid line represents the ROC curve for all risk factors combined including the POMA test. There was no significant difference between the two AUC's from these two curves (0.72 versus 0.76; chi-square 0.33; $P = 0.56$).

The proportion of patients remaining free of severe falls over time, according to age category, and censored for death and transplantation is shown in Figure 3. After a maximal follow-up time of 1000 days (mean follow-up time 465 days), 89.1% were free of falls in the category <65 years, versus 57.2% in the category 65–75 years and only 30.2% in the category >75 years (log-rank test $P = 0.002$).

The relationship between the number of risk factors per patient and the percentage of falls per risk category was analysed separately. For this analysis, only risk factors with a P-value ≥0.05 in univariate analysis were considered, i.e. age >65 years, malnutrition, depression and a history of falls. During the study period, patients without any of these risk factors ($n = 12$) did not experience severe falls. In contrast, patients with 4 risk factors ($n = 3$) all fell. Those with 1, 2 and 3 risk factors had intermediate risks of, respectively, 22.6, 11.8 and 61.5% of falls per category.

## Discussion

The main findings of our study were that (i) severe falls were frequent in MHD patients (incidence of 0.22 per patient-year) and resulted in more than half of the cases in fractures; (ii) predialysis POMA scores were low and dropped further after a dialysis session; (iii) severe falls were associated with ageing, depression, a history of falls and malnutrition; (iv) the POMA score was not an independent predictor of severe falls in this study, although there was a trend towards lower POMA scores in fallers as compared to non-fallers; (v) a POMA score >21 predicted the ability of the patients to remain free of severe falls.

Despite the fact that MHD patients present many classical risk factors for falls, very few studies have evaluated prospectively the risk of severe falls in this population. Furthermore, to our knowledge, this is the first study that has used the POMA test to evaluate the risk of severe falls in this population.

Cook *et al.* [10] reported an incidence of falls (severe and not severe) of 1.60 per patient-year in 162 Canadian MHD patients (mean age 74.7 years) followed prospectively for a median of 468 days. Falls that required an emergency department visit occurred in 12.5% corresponding to an incidence of 0.20 per patient-year. This incidence was similar to ours (0.22 per patient-year), although our study population was younger. Desmet *et al.* [11] conducted a prospective multicentre study in Belgium in 308 MHD patients (median age 70.9 years) and found a cumulative

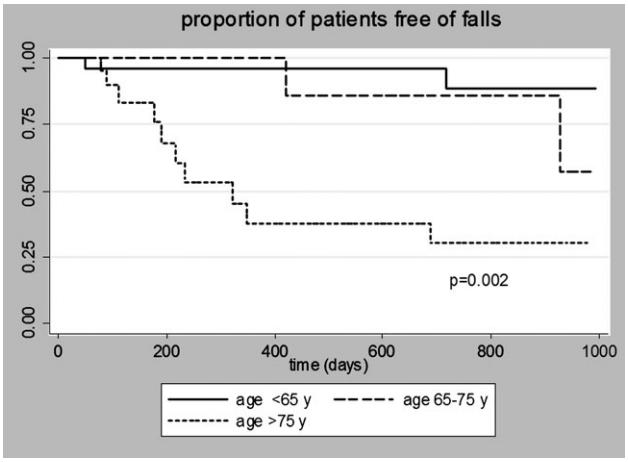


**Fig. 3.** Kaplan–Meier curves showing the proportion of patients free of falls, after censoring for deaths and transplantations, according to age category (log-rank test P = 0.002).

incidence of falls of 1.18 per patient-year and of 0.37 per patient-year for falls requiring medical care. This is slightly higher than the incidence of severe falls in our study. Overall, considering these three studies, the incidence of severe falls appears to be 0.20–0.37 per patient-year and the incidence of all falls of 1.2–1.6 per patient-year in the MHD population.

In the general population, the incidence of falls has been more thoroughly studied. The largest prospective trial by Tinetti *et al.* included 336 non-uraemic persons aged >75 years. Tinetti *et al.* [2] reported an incidence of 0.32 falls per patient-year, of which 30% were severe. These comparative data suggest that the incidence of falls is four times higher in MHD patients and that of severe falls up to two to three times higher than in elderly patients from the general population.

The high incidence of (severe) falls in the MHD population can be explained in several ways. It could be due to the fact that patients on MHD present more traditional risk factors or because they are exposed to unique external factors related to HD such as the frequent transportations to and from the dialysis unit and the repetitive aggressive fluid shifts during HD sessions. In the study of Desmet *et al.* [11], age, diabetes, antidepressant drug use and walking test were independent risk factors for falls. In our study, age, depression malnutrition and a past history of falls were significant independent risk factors, whereas diabetes was not. Advanced age is described as a major risk factor for falls in studies conducted in the general population as well [1, 12].

The POMA test is an easily reproducible clinical tool which has been shown to predict the risk of (severe) falls in non-uraemic persons [13, 15]. No studies have investigated the value of this score to predict falls in MHD patients. Our data show that the POMA test is an interesting tool in the MHD population: median scores were low and dropped further after an HD session. This drop in score might be related to the shifts in electrolytes and fluid that occur during a session, which may induce dizziness, hypotension and arrhythmias, all factors capable of increasing the risk of falls. However, in our study, severe falls did not occur more frequently in the first 24 h after a dialysis session than in the next 24 or 48 h. Nevertheless, ~20% of the severe falls occurred in the dialysis centre which may argue in favour of this hypothesis. In addition, we used a slightly adapted POMA score, with a maximum score of 26 instead of 28 points, which might partly explain the low POMA scores in MHD patients as compared to the general population. Moreover, several POMA tests with varying cut-off values and scores are reported in the medical literature, which makes comparison of studies difficult [20]. The relatively high negative predictive value of the test fairly predicted the patients who remained free of severe falls during the follow-up. However, the low positive predictive value and specificity were limitations of the POMA test. Furthermore, in our study, the POMA test was not associated with severe falls in univariate analysis. This might be due to the limited size of our population or due to the fact that we have only collected severe falls. Taken together, the test alone could not accurately determine which patients will fall, but in the case of a score <21, high attention should be warranted and efforts should be made to reduce individual risk factors. In contrast, a score >21, if not associated with risk factors as defined in our study, may predict that the patient is not going to fall. Finally, the timing to perform the POMA test in MHD may warrant further investigations, as it appeared significantly lower post-dialysis in a subgroup of patients. It would be thus interesting to test the value of POMA scores systematically collected after an HD session in predicting falls in these patients.

The presence of several risk factors in the same individual significantly increased the risk of severe falls in our study. Tinetti *et al.* and Covinsky *et al.* also observed that the risk of falls increases linearly with the number of risk factors [2, 3]. The four major risk factors identified in our study were malnutrition, depression and a history of falls and age ≥65 years. None of the patients without these risk factors fell severely, whereas all patients with four risk factors fell severely. The cumulative score combining several risk factors thus appeared to predict the risk of severe falls. However, these data may not, at this stage, be applicable to all patients on MHD since derived from a single-centre study; and these need confirmation in larger prospective multicentre studies.

This study has some limitations. As mentioned, the relatively limited number of patients included in this single-centre study may have decreased its statistical power to define predictive values for severe falls in this population. Furthermore, the collection of severe falls and not all falls has possibly limited the statistical power of the study. In addition, we did not report the use of psychotropic medications which is a known risk factor in the general population, nor we did assess vitamin D status which has been recently identified as a risk factor for falls in the general population. However, virtually, all patients with depression, which was recorded, were on psychotropic drugs. In addition, the clinical significance of 25-hydroxyvitamin D deficiency in the MHD population is still controversial. Another limitation is that a previous validation of the POMA test has not been performed in MHD patients

and indeed, the current results do not help to validate the POMA score as a predictor of falls. Finally, the post-dialysis POMA test appeared interesting but it was only explored in a subgroup of patients. The strengths of the study are the prospective design, the completeness of follow-up data and the application for the first time of a systematic POMA test in this population.

In conclusion, we report that the incidence of severe falls is high in the MHD population and that these falls often result in complications such as fractures and even death. High age, malnutrition, depression and a history of falls are associated with severe falls, and the presence of several of these risk factors in the same patient further increase the risk of severe falls. The POMA test is an easily reproducible tool which may help to identify patients who will not fall, although it is not an independent predictor of severe falls in this study. The identification of this combination of risk factors may help to target interventions to a subgroup of patients, such as intensive screening, the management of depression, exercise programmes and/or nutritional support in order to prevent this important complication.

*Conflict of interest statement*. None declared.

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