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ORIGINAL ARTICLE

Development of a predictive model for early death in diabetic patients entering hemodialysis: a population-based study

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Abstract The aim of this study was to investigate whether early death following the start of dialysis treatment can be explained by predialysis comorbid conditions, and to develop a prognostic model to predict early death in these patients. All patients with diabetes mellitus (DM) over 19 years of age entering hemodialysis in Catalonia in the 1997–2002 period ($n = 1{,}365$) were assessed from prospectively obtained data in the Catalan Renal Registry. Logistic regression was used to identify the risk factors associated with mortality at 3, 6 and 12 months of hemodialysis. Mortality at 3 months was found to be associated with age (RR: 1.53/10 years), low grades of functional autonomy, defined as "limited" (RR: 2.28) or "special care" (RR: 4.60), heart disease (RR: 2.23), and use of a catheter as the first vascular access (RR: 2.45). Malignant conditions and malnutrition were found to be additional significant risk factors for mortality at 12 months (RR: 1.68 and 1.74, respectively). Based on the multivariate analysis results, an individual prognostic model was formulated. This study confirms previous data suggesting that predialysis comorbid conditions are significantly associated with mortality in DM patients on dialysis and provides a prognostic model to help clinicians focus on various factors that may require attention before initiating this treatment.

Keywords Hemodialysis · Mortality · Diabetes mellitus · Risk factors modeling · Epidemiology

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Introduction

Overall mortality rates in patients on renal replacement therapy (RRT) vary between countries [1]. Despite these differences, it is widely agreed that mortality in diabetic patients is higher than in the non-diabetic population receiving RRT [2–7].

In patients receiving dialysis therapy this higher mortality is associated with, and may be explained at least in part by higher morbidity, which is either pre-existent [7] or produced during the period on RRT [6], but little is known about the predictive capacities derived from factors specific to end-stage renal disease (ESRD) present at the start of RRT.

There are few published studies investigating overall or specific comorbid conditions in predialysis end-stage diabetic patients and the relationship between comorbidity and later causes of death in this population [4, 7–9]. Interestingly, the available data suggest the need to identify the individual risk of death for each comorbid factor with the aim of improving predialysis care [10, 11]. Recent registry data have reported higher morbidity and mortality rates in diabetes mellitus (DM) patients 90 days after starting RRT as compared to non-diabetic patients [4]. Nevertheless, because of the low percentage of responses related to comorbidity, these findings should be confirmed.

The objectives of this study are to identify whether the mortality rate at 3, 6 and 12 months in diabetic patients on

hemodialysis therapy may be explained by comorbid conditions and ESRD-specific factors present at the start of hemodialysis, and to develop a prognostic model that profiles individual predialysis risk as a predictor of early mortality.

Material and methods

This is a prospective study based on data from all diabetic patients over 19 years old starting chronic hemodialysis treatment in Catalonia along the period of 1997–2002 ($n = 1{,}387$). Early mortality end-points were set at 3, 6 and 12 months.

The data source used for this study is the Catalan Renal Registry (RMRC, *Registre de Malalts Renals de Catalunya*), created in 1984 by the Health Department of the Government of Catalonia. Notification to the RMRC is mandatory for all public and private centers at the initiation of RRT and yearly thereafter.

Morbid conditions are grouped according to the International Classification of Diseases (ICD-9) coding (Appendix A). Functional autonomy grade is assessed with Gutman's modification of the Karnofsky Index for renal patients [12].

The following risk factors were studied: DM type, age, sex, heart disease, stroke, peripheral vascular disease, malignant processes, chronic liver disease, chronic obstructive pulmonary disease (COPD), tuberculosis, arthropathy, intestinal disease, esophageal, gastric and duodenal diseases, malnutrition (BMI < 20), obesity (BMI > 30), presentation form of ESRD (acute is attributed to a lack of predialysis nephrological care, whereas subacute or normal progression implies predialysis nephrological care during at least 6 months), grade of functional autonomy and first vascular access. A differentiation was made between temporary and permanent catheters (catheter group) and between autologous arteriovenous fistula and vascular graft (AVF group). Age was taken as a continuous variable and, following analysis of the linear pattern, was divided into 10-year units for the logistic regression analysis. To ensure comparability among the new patients starting hemodialysis, the frequency of the variables evaluated was checked yearly along the study period (1997–2002).

Statistics

The chi-square test was used to compare proportions. Logistic regression was applied to analyze the risk factors for death. DM type, age and sex were present as adjusting factors in all three models (3-, 6- and 12-month risk). Variables with a non-significant likelihood ratio test ($P > 0.05$) in all three models were eliminated one by one from the multivariate model. Thus, a variable that was found to be significant in one model was introduced in the other models as a potential correction factor.

An examination of all possible two-way interactions among these main effects determined that none satisfied all our criteria (statistical and clinical plausibility) for inclusion in the model.

Calibration of the models was assessed with the Hosmer–Lemeshow goodness-of-fit test, which determines the accuracy of the statistical probabilities generated by the model studied; that is, it compares the predicted number of patient deaths with the actual number observed for each decile of risk [13]. Discrimination was assessed using the area under the receiver operating characteristic (ROC) curve to evaluate how well the model recognized patients who died at 3, 6 and 12 months [14]. Statistical analyses were performed using SPSS software, version 12.01.

The predicted probability of death at 3, 6, and 12 months was generated from the estimated beta-coefficients of the model variables with the following formula:

$$\Pi(X) = \frac{e^{\beta o \pm \beta 1 x}}{1 + e^{\beta o + \beta 1 x}}$$

in which β are the coefficients and Π is the probability.

The feasibility of obtaining a prognostic probability of death at 3, 6 and 12 months from complex RRT starting morbid conditions was analyzed by combining the individual beta coefficient as seen for each morbid factor and model, and expressing the result by a curve representing the risk of death (Appendix B).

Results

Twenty-two patients who moved out of Catalonia before ending the first year of RRT were excluded as lost to follow-up. Information on all the variables relevant to this study was available from 1,290 diabetic patients among the remaining 1,365 initiating dialysis (94.5%). The yearly frequency of morbid conditions present before dialysis was similar ($P > 0.05$) over the years comprising the study period (1997–2002).

Among the total of patients studied, 566 (43.9%) had started dialysis with an autologous arteriovenous fistula, 17 (1.3%) with a vascular graft, 68 (5.3%) with a tunneled catheter and 639 (49.5%) with a temporary catheter.

Significant differences in the type and number of morbid conditions at the start of RRT were found between patients with type 1 DM and type 2 DM. Type 2 patients were older, had a higher frequency of heart disease, stroke, arthropathy, COPD, chronic liver disease, and gastric, duodenal and esophageal diseases, greater functional disability, and more

Table 1 Demography and characteristics of incident diabetes mellitus patients (1997–2002)

	DM-1		DM-2		P
	n		*n*		
Mean age	165	49.7	1,178	69.5	<0.00001
Women	51	30.9%	458	38.9%	0.05
Cardiac morbidity	68	41.2%	749	63.3%	<0.00001
Stroke	17	10.3%	237	20.1%	0.002
Peripheral vascular disease	78	47.3%	598	50.8%	0.4
Malignances	9	5.5%	100	8.5%	0.2
Chronic liver disease	22	13.3%	96	8.1%	0.04
COPD	12	7.3%	247	21.0%	<0.00001
Arthropathy	20	12.1%	309	26.2%	<0.00001
Intestinal disease	5	3.0%	68	5.8%	0.2
Esophageal, gastric and duodenal disease	10	6.1%	155	13.2%	0.008
Tuberculosis	1	0.6%	23	2.0%	0.4
Malnutrition (BMI < 20)	18	11.1%	84	7.5%	0.1
Obesity	21	13.0%	192	17.1%	0.2
Presentation of ESRD					
Normal progression	113	70.2%	722	62.1%	0.1
Subacute	39	24.2%	380	32.7%	
Acute	9	5.6%	61	5.2%	
Catheter as first VA	71	43.8%	652	55.9%	0.004
GFA					
Normal	98	59.4%	447	38.0%	<0.00001
Limited	42	25.5%	451	38.3%	
Special care	25	15.2%	279	23.7%	

COPD chronic obstructive pulmonary disease, *BMI* body mass index, *DM* diabetes mellitus, *ESRD* end-stage renal disease, *GFA* grade of functional autonomy, *VA* vascular access

frequently started dialysis with a catheter as the first vascular access (Table 1).

The all-causes crude mortality in patients starting RRT in the period 1997–2002, expressed as the number of deaths per 100 patient-years, was 16.03 in DM type 1 and 23.07 in DM type 2. In both types of diabetes, death was most often due to heart disease, vascular disease and infection. A cardiovascular condition was the cause of 70% of deaths among patients with DM type 1 and 50% of deaths in patients with DM type 2 (Table 2). Furthermore, cardiovascular mortality in patients aged 20–50 years was found to be similar to the overall mortality rate, whereas in patients older than 50 the proportion of cardiovascular deaths progressively decreased with increasing age (Fig. 1). In DM type 2 patients, social factors (mainly RRT interruption) were found to be a significant cause of death (Table 2).

Table 2 Causes of death according to diabetes type, per 100 patient-years

	DM-1	DM-2
Cardiac	9.00	7.73
Vascular (mainly stroke)	2.18	4.10
Infection	1.21	3.73
Social (mainly RRT interruption)	0.97	2.10
Malignant disease	1.21	1.00
Miscellaneous	0.49	1.68
Unknown	0.97	2.73
Total	16.03	23.07

Incident patients, 1997–2002

DM diabetes mellitus

Logistic regression was used to identify the risk factors associated with early death at 3, 6 and 12 months of hemodialysis. The variables stroke, peripheral vascular disease, chronic liver disease, COPD, tuberculosis, arthropathy, gut disease, gastroduodenal disease, obesity and ESRD presentation were eliminated from the model on the basis of the criteria outlined in "Material and methods".

The Hosmer and Lemeshow test results demonstrated good calibration and goodness-of-fit for all the models studied ($P = 0.90$ for 3-month, $P = 0.96$ for 6-month, and $P = 0.22$ for 12-month). The area under the ROC curves for the models was 0.77, 0.75 and 0.76, respectively, indicating appropriate discrimination among patients who died at 3, 6 and 12 months after starting treatment.

In the multivariate analysis, age was a significant risk factor for early death in diabetic dialysis patients. The probability for death increased by 40–53% per each 10-year age unit. Predialysis functional disability was an important predictor of death, particularly in patients requiring special care (OR 4.60–3.66). The presence of heart disease (arrhythmia, myocardial disease, ischemic coronary disease) before initiating dialysis was also a strong predictor of early death, with a 2.23-fold, 2.08-fold and 1.89-fold risk increase at 3, 6 and 12 months, respectively. Starting dialysis with a catheter as the vascular access increased the probability of death in all three models (OR 2.45, 2.22, 2.26, respectively). Malignant conditions and malnutrition (BMI < 20) were only significant in the 12-month model (OR 1.68 and 1.74, respectively) (Table 3).

On the basis of these models, curves can be constructed to predict mortality in specific patients about to start dialysis (Fig. 2).

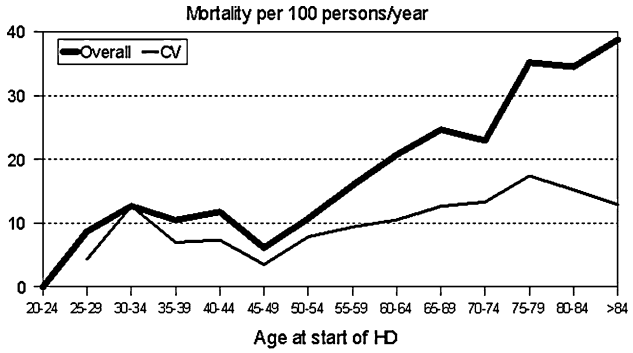

Fig. 1 Overall mortality and cardiovascular mortality by age group

Discussion

This study was undertaken to analyze the risk factors associated with early mortality in diabetic patients starting hemodialysis, including both comorbid conditions and other specific factors inherent to hemodialysis treatment. The factors found to be related with early death were patient age, grade of functional autonomy, presence of cardiac or malignant disease, malnutrition and the fact of using a catheter as the first vascular access. There were no differences in the risk factors identified between the two types of DM.

Other reports investigating registry data concur with the relationship between survival and the number and type of comorbid conditions present at the start of dialysis [4]. Moreover, studies in diabetic patients have related specific diseases at the start of dialysis with specific causes of death [10, 11]. Among the morbid conditions found in our renal patients, there was high incidence and prevalence of heart disease, which is known to be associated with substantial hospitalization rates in these patients [2, 3]. Neoplasms and malnutrition affected a smaller number of cases.

In the overall population of patients with ESRD, the fact of having a first contact with the nephrologist at three or four months before starting RRT is associated with higher early mortality [15–17]. The increased mortality associated with late referral is attributed to poor control of the comorbid conditions and factors specifically related to ESRD [18].

It is well recognized that the use of a catheter for first vascular access (50% in our study) is closely related with late referral to the nephrologist, but in our setting it is also the result of organizational problems in the health system (coordination among specialists and lengthy waiting lists in vascular surgery departments).

First-year mortality was also found to be related to the type of vascular access used for starting dialysis, in keeping with the findings from other studies [19, 20]. Starting dialysis with a catheter doubled the risk of death in the first year.

The association between late referral and early mortality is also assumed to hold true specifically for diabetic

Table 3 Logistic regression analysis of risk of death at 3, 6 and 12 months following start of dialysis start

	Mortality 90 days		Mortality 6 months		Mortality first year	
	RR	95% CI	RR	95% CI	RR	95% CI
Sex						
Male	1	–	1	–	1	–
Female	1.12	0.67–1.85	0.94	0.64–1.38	0.86	0.63–1.17
Age (10 years)	1.53	1.10–2.13	1.40	1.10–1.78	1.51	1.25–1.83
GFA						
Normal	1	–	1	–	1	–
Limited	2.28	1.01–5.01	2.33	1.38–3.94	1.99	1.35–2.95
Special care	4.60	2.10–10.1	3.62	2.10–6.26	3.86	2.56–5.84
Morbidity						
Cardiac disease	2.23	1.16–4.29	2.08	1.32–3.28	1.89	1.34–2.66
Malignant disease	1.73	0.77–3.89	1.33	0.70–2.52	1.68	1.01–2.78
Malnutrition (BMI < 20)	1.25	0.58–2.72	1.58	0.89–2.80	1.74	1.07–2.83
First vascular access						
Arteriovenous fistula/graft	1	–	1	–	1	–
Catheter	2.45	1.37–4.38	2.22	1.48–3.35	2.26	1.65–3.11
Type of DM						
DM type 1	1	–	1	–	1	–
DM type 2	0.75	0.26–2.14	0.96	0.43–2.14	0.69	0.37–1.27

BMI body mass index, *DM* diabetes mellitus, *GFA* grade of functional autonomy

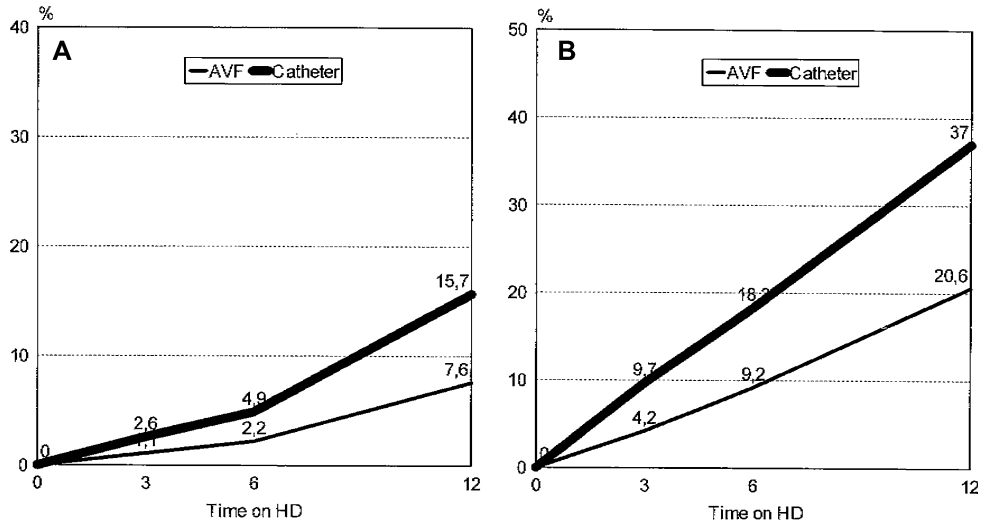

Fig. 2 Examples of probability of death estimates at 3, 6 and 12 months using the predictive model: **a** 49-year-old man, DM-1, normal functional status, with heart disease, analyzed according to type of first vascular access; and **b** 69-year-old man, DM-2, limited functional status, with heart disease, analyzed according to first vascular access. Note: In **a**, probability of death at 1 year with AVF as first vascular access: $\beta o + \beta_1 x = -5.159 - 0.153 \times \text{Sex} + 0.414 \times \text{Age}/10 + 0.690 \times \text{GFA\_limited} + 1.352 \times \text{GFA\_Special\_Care} + 0.636 \times \text{Cardiac\_Disease} + 0.517 \times \text{Malignacies} + 0.553 \times \text{Malnutrition} + 0.816 \times \text{First\_Vascular\_Access} - 0.372 \times \text{DM\_type}$. $\beta o + \beta_1 x = -5.159 - 0.153 \times 0 + 0.414 \times (49/10) + 0.690 \times 0 + 1.352 \times 0 + 0.636 \times 1 + 0.517 \times 0 + 0.553 \times 0 + 0.816 \times 0 - 0.372 \times 0 = -2.4944$. $\Pi(x) = e^{-2.4944}/(1 + e^{-2.4944}) = 7.63\%$

patients receiving hemodialysis. Nevertheless, in the present study, this relationship unexpectedly disappeared when the model was adjusted for the type of vascular access used to start dialysis. We believe this may have occurred because of the link between these two factors and the small number of patients in this cohort who were referred late to the nephrologist (only 5% of the entire series).

Various indexes are available to measure the severity of morbidity [e.g., the index of coexistent diseases (ICED) and Charlson Index], and these are widely accepted as tools to predict mortality risk; nevertheless, they were not specifically designed for diabetics receiving dialysis. Although some of these indicators have been adapted for patients receiving dialysis treatment [9, 21–23], they do not include certain factors that are specific to these patients and that could substantially modify the risk of death (e.g., first vascular access, malnutrition, late referral, and functional autonomy). In the present study we have attempted to resolve this gap by adding these specific factors to the model.

The Renal Registry of Catalonia is a mandatory population registry that records information on all patients receiving RRT in Catalonia. In 1988, the Registry underwent an external validation process, which showed exhaustive notification of relevant variables and excellent agreement [24].

Population registry-based studies are unbiased for case selection and offer the true incidence of a set of variables collected periodically in a complete sample; hence, there is no need to demonstrate that the population examined is representative. Nonetheless, they are limited by the fact that only the variables contained in the registry are available for study and some of these may lack specificity for the proposed goal of the investigation. The ICD-9 disease classification was the basis for recording co-morbid conditions in the registry that provided the data for the present study. This system facilitates homogeneity at the time the information is collected, but the fact of grouping diagnoses into a defined number of variables and excluding the severity of the conditions implies a limitation in the data available for subsequent analysis. Despite these limitations, the variables used in this study are those required to develop the proposed aims, and suffice to derive solid conclusions. Subsequent, ongoing efforts to validate the models for early mortality will determine their grade of general applicability.

Based on the data obtained with this analysis, it seems evident that application of corrective measures for modifiable morbid factors in the predialysis consultations would be an appropriate preventive measure. It is possible that the probability of survival of many patients suffering from arrhythmia, heart failure, severe valvular disease, angina, or some forms of reversible blindness would improve with active policies of detection and control of these conditions. Similarly, the high rate of cardiovascular mortality observed in young diabetic patients (higher than that of older patients) might indicate that more intensive treatment of ischemic coronary disease is required in this group.

During the first months of dialysis therapy many of the risk factors are corrected: arteriovenous fistulas are implanted, nutritional status improves, and cardiac revascularization is performed. Nevertheless, despite these efforts, early mortality remains essentially unchanged in these patients as compared to those starting dialysis without these factors.

Using the risk factors for early mortality in individuals starting dialysis identified in this analysis, we have developed a predictive model designed to be easily interpreted by clinicians in predialysis for use as an aid to determining the interventions required. Identification of the associated risk of each comorbid factor allows determination of the specific mortality risk for each individual. This approach is not typical in clinical practice, but is widely used by insurance companies [25].

The graphs obtained with these risk estimations provide a visual representation of the probability a specific individual has for death during the first year of hemodialysis, as well as the reduction in risk that would occur if certain factors were modified.

Additionally, in our specific setting, the information obtained with this model can be highly useful to the health authorities, allowing implementation of strategies that will improve coordination among the various levels of health care assistance and leading to better use of the resources destined for reducing risk in ESRD patients.

Conclusions

Within the limitations inherent to any registry-based data study, the following factors were found to be related to all-cause early death in patients about to initiate dialysis: use of a catheter as the first vascular access, cardiac disease, malignant disease, and malnutrition. With the models developed in this study, it is possible to estimate the risk of death in individual diabetic patients at the start of ESRD according to their characteristics, co-morbid conditions, and other factors specific to the progression of the disease and its treatment. Knowledge of a patient's risk at predialysis consultations can facilitate the application of more intensive preventive strategies focused on correcting the factors implicated and help to set the priorities for using available resources, with the ultimate aim of improving survival in these patients.

Appendix A

Morbidity by ICD-9 codes

Heart disease (codes: 410–414 and 425–428), cerebrovascular disease (codes: 430–438 and 342); vascular disease (codes: 440, 441 and 443); chronic obstructive pulmonary disease (COPD) (codes: 491–496); tuberculosis (codes: 10–18); malignant disease (codes: 140–208); cirrhosis and other chronic liver diseases (codes: 571); arthropathy (codes: 712, 714 and 715); esophageal, gastric and duodenal diseases (codes: 530–537); intestinal disease (codes: 562 and 569)

Appendix B: Table 4

Table 4 Predictive models at 90 days, 6 months and 1 year

	β: 90 Days	6 Months	1 Year
Sex (female)	0.110	−0.060	−0.153
Age	0.423	0.337	0.414
Funct. autonomy grade			
Limited	0.824	0.846	0.690
Special care	1.525	1.288	1.352
Cardiac disease	0.803	0.731	0.636
Malignant disease	0.550	0.282	0.517
Malnutrition	0.226	0.456	0.553
Catheter	0.895	0.799	0.816
DM (2)	−0.289	−0.043	−0.372
βo	−7.378	−6.156	−5.159

References

1. Rayner HG, Pisoni RL, Bommer J, Canaud B, Hecking E, Locatelli F, Piera L, Bragg-Gresham JL, Feldman HI, Goodkin DA, Gillespie B, Wolfe RA, Held PJ, Port FK (2004) Mortality and hospitalization in haemodialysis patients in five European countries: results from the dialysis outcomes and practice patterns study (DOPPS). Nephrol Dial Transplant 19:108–120
2. U.S. Renal Data System (2005) USRDS 2005 annual data report: atlas of end-stage renal disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD. http://www.usrds.org/adr.htm
3. ANZDATA 28th Report (2005) Australia and New Zealand Dialysis and Transplant Registry. Adelaide. South Australia. http://www.anzdata.org.au/ANZDATA/AnzdataReport/download.htm
4. UK Renal Registry Report (2004). UK Renal Registry, Bristol, UK. http://www.renalreg.com
5. Van Dijk PC, Jager KJ, Stengel B, Gronhagen-Riska C, Feest TG, Briggs JD (2005) Renal replacement therapy for diabetic end-stage renal disease: data from 10 registries in Europe (1991–2000). Kindney Int 67:1489–1499
6. Rodríguez JA, Clèries M, Vela E, Renal Registry Committee (1997) Diabetic patients on renal replacement therapy: analysis of Catalan Registry data. Nephrol Dial Transplant 12:2501–2509

7. Catalan Renal Registry 21st Report 2004 (2006) Catalan Health Department, Catalan Government. http://www10.gencat.net/catsalut/ocatt/en/htm/est_pub_trans_renal.htm
8. Khan I (1998) Co-morbidity: the major challenge for survival and quality of life in end-stage renal disease. Nephrol Dial Transplant 13:76–79
9. Miskulin DC, Meyer KB, Martin AA, Fink NE, Coresh J, Powe NR, Klag MJ, Levey AS, for the Choices for Healthy Outcomes in Caring for End-Stage-Renal-Disease (CHOICE) Study (2003) Comorbidity and its change predict survival in incident dialysis patients. Am J Kidney Dis 41:149–161
10. Koch M, Thomas B, Tschope W, Ritz E (1993) Survival and predictors of death in dialysed diabetic patients. Diabetologia 76:1113–1117
11. Morioka T, Emoto M, Tabata T, Shoji T, Tahara H, Kishimoto H, Nishisawa E, Ishimura Y (2001) Glycemic control is a predictor of survival for diabetic patients on hemodialysis. Diabetes Care 24:909–913
12. Gutman RA, Stead WW, Robinson RR (1981) Physical activity and employment status of patients on maintenance dialysis. N Engl J Med 304:309–313
13. Hosmer DW, Lemeshow S (1989) Applied logistic regression. Wiley, New York
14. Hanley JA, McNeil BJ (1982) The meaning and use of the area under a receiver operating characteristics (ROC) curve. Radiology 153:29–36
15. Kazmi WH, Obrador GT, Khan SS, Pereira BJ, Kausz AT (2004) Late nephrology referral and mortality among patients with end-stage renal disease: a propensity score analysis. Nephrol Dial Transplant 19:1671–1673
16. Ritz E (2005) Managing and diabetes: a future challenge for nephrologists. Nephrol Dial Transplant 20:vi21–vi25
17. Lameire N, Van Biesem W (1999) The pattern of referral of patients with end-stage renal disease to the nephrologist—a Europe survey. Nephrol Dial Transplant 14:16–23
18. Mauri JM, Clèries M, Vela E, Catalan Registry of Renals Patients (2005) Mortality risk factors for the first year of hemodialysis treatment in Catalonia. Nephrol Dial Transplant 20:v295 (Abstract)
19. Xue JL, Dahl D, Ebben JB, Collins AJ (2003) The association of initial hemodialysis access type with mortality. Outcomes in elderly. Medicare ESRD patients. Am J Kidney Dis 42:1013–1019
20. Lorenzo V, Martin M, Rufino M, Hernández D, Torres A, Ayus JC (2004) Predialysis nephrologic care and functioning arteriovenous fistula at entry are associated with better survival in incident hemodialysis patients: an observational cohort study. Am J Kidney Dis 43:999–1007
21. Van Manen JG, Korevaar JC, Dekker FW, Boeschoten EW, Bossuyt PMM, Krediet RT, for the Necosad Study Group (2003) Adjustment for comorbidity in studies on health status in ESRD patients: which comorbidity index to use? J Am Soc Nephrol 14:478–485
22. Hemmelgarn BR, Mabbs BJ, Quan H, Ghali WA (2003) Adapting the Charlson comorbidity index for use in patients with ESRD. Am J Kidney Dis 42:125–132
23. Miskulin DC, Martin AA, Brown R, Fink NE, Coresh J, Powe NR, Zager PG, Meyer KB, Levey AS, the Medical Directors of Dialysis Clinic, Inc (2004) Predicting one-year mortality in an outpatients haemodialysis population; a comparison of co-morbidity instruments. Nephrol Dial Transplant 19:413–420
24. Aubia J, Puig JM, Clèries M, Vidal C, Vela E, Salvador X, Ramis O (1991) Cómo validar un registro de enfermos renales: consideraciones a propósito del audit del Registro de enfermos renales de Catalunya. Nefrologia XI:332–339
25. Schuchter L, Schultz DJ, Synnestvedt M, Trock BJ, Guerry D, Elder DE, Elenitsas R, Clark WH, Halpern AC (1996) A prognostic model for predicting 10-year survival in patients with primary melanoma. Ann Intern Med 125:369–375