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Original Article

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Quality of care and survival of haemodialysed patients in western Switzerland

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Abstract

Background. Many factors affect survival in haemodialysis (HD) patients. Our aim was to study whether quality of clinical care may affect survival in this population, when adjusted for demographic characteristics and co-morbidities.

Methods. We studied survival in 553 patients treated by chronic HD during March 2001 in 21 dialysis facilities in western Switzerland. Indicators of quality of care were established for anaemia control, calcium and phosphate product, serum albumin, pre-dialysis blood pressure (BP), type of vascular access and dialysis adequacy (spKt/V) and their baseline values were related to 3-year survival. The modified Charlson co-morbidity index (including age) and transplantation status were also considered as a predictor of survival.

Results. Three-year survival was obtained for 96% of the patients; 39% (211/541) of these patients had died. The 3-year survival was 50, 62 and 69%, respectively, in patients who had 0–2, 3 and $\geq$4 fulfilled indicators of quality of care (test for linear trend, $P < 0.001$). In a Cox multivariate analysis model, the absence of transplantation, a higher modified Charlson's score, decreased fulfilment of indicators of good clinical care and low pre-dialysis systolic BP were independent predictors of death.

Conclusion. Good clinical care improves survival in HD patients, even after adjustment for availability of transplantation and co-morbidities.

Keywords: co-morbidity score; end-stage renal failure; haemodialysis; quality of care; survival

Introduction

Survival in patients with end-stage renal failure (ESRF) treated by chronic dialysis is notoriously poor. For example, in Europe, survival rates are 82% at 1 year and 47% at 5 years [1]. Some of the excess mortality in haemodialysis (HD) patients is due to the high prevalence of cardiovascular and other co-morbidities, but the quality of care they receive is also critical. Dialysis practice guidelines have been developed and disseminated [2–4] and systematic measurements of clinical performance, relying on indicators such as levels of Kt/V, haematocrit and serum albumin, have been implemented. These indicators reflect the quality of relevant health care processes (i.e. amount of dialysis, treatment of anaemia, nutritional level) and they correlate with patient mortality and morbidity [5–8].

However, most studies of patient survival conducted to date did not account for all relevant quality of care criteria and patient characteristics. Furthermore, the relative importance of quality of care and patient characteristics for patient survival is not well understood. The impact of attaining multiple performance targets has been evaluated recently in two observational studies in prevalent and incident patients, where mortality and hospitalization rates were higher with increasing number of unfulfilled therapeutic targets in a dose-dependent manner [9,10]. In addition to quality of care, patient characteristics such as age, gender, body mass index (BMI) and blood pressure (BP) may also affect survival. Recently, a simple co-morbidity score, the modified Charlson co-morbidity index, has been validated in the dialysis population [11].

The aim of this study was to identify whether good clinical care affects survival in HD patients after adjustment for the modified Charlson co-morbidity index, gender, BMI, kidney transplantation and duration of renal replacement therapy.

Subjects and methods

Study design and population

This prospective study is based on the cohort of all ESRF patients haemodialyzed in western Switzerland for whom a detailed assessment of quality of care was performed in March 2001 [12]. This project was approved by the

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research ethics committees of the Universities of Lausanne and Geneva.

Study variables

The dependent variable was survival between March 2001 and April 2004.

Variables used as quality criteria for individual patients were recorded in six domains of clinical care:

1. *Dialysis adequacy*: for HD patients, the single pool (sp) Kt/V was calculated using the sp Daugirdas II method based on post-dialysis plasma samples drawn after slowing the blood pump to 50 mL/min for 2 min. A sp $Kt/V \geq 1.2$ was considered adequate.
2. *Appropriate anaemia management*: assessed by achieved haemoglobin levels. When several measures were recorded during the past month, the average was used for the determination. A haemoglobin $\geq$110 g/L or a haematocrit $\geq$33% was considered adequate.
3. *Calcium and phosphate metabolism*: assessed by the calcium–phosphate product. A value of <4.4 mmol^2/L^2, using pre-dialysis serum calcium and phosphorus levels, was considered adequate.
4. *Nutrition*: assessed by the serum albumin. A level $>$35 g/L was considered to be a criterion of good nutrition.
5. *Vascular access*: defined by the presence of a native arteriovenous fistula (AVF), a synthetic graft or a catheter. Dialysis via a native AVF was considered optimal.
6. *Hypertension control*: assessed by the mean pre-dialysis BP over 1 week. Hypertension was defined as the mean pre-dialysis BP $>$140/90 over 1 week.

Additional predictor variables were patient age, gender, cause of renal failure, time on renal replacement therapy, type of membranes (an *in vitro* ultrafiltration coefficient $>$20 mL/min was used to separate between low-flux and high-flux membranes), pre-dialysis nephrologist referral (referral $<$1 month prior to HD implementation was defined as late), placement on waiting list for transplantation, actual transplantation and presence of medical conditions that allow computation of the modified Charlson co-morbidity index [11]. This index scored 1 for all forms of coronary artery disease as well as congestive heart failure, peripheral vascular and cerebrovascular diseases, dementia, chronic pulmonary disease, connective tissue disorder, peptic ulcer disease, mild liver disease and diabetes. Haemiplegia, diabetes with organ damage, any tumour, leukaemia and lymphoma were scored 2. Moderate or severe liver disease was scored 3 and AIDS or metastatic solid tumour was scored 6. We added 2 points for ESRF and 1 for each decade $>$40 years of age. This modified index was recently validated for predicting outcomes and costs in dialysis patients [11]. We stratified the modified Charlson score into three levels (2–5, 6–9 and $>$9).

Data collection

At baseline, patient-level data were collected by means of a questionnaire completed by the centre team based on each patient's medical and nursing records. Data on 3-year survival and transplantation were subsequently obtained for these patients by referring to their medical records.

Data analysis

Descriptive statistics were used to represent demographic and clinical characteristics of the study population.

Variables used as indicators of good clinical care were dichotomized as being or not in conformity with the desired range set by the guidelines as reference value. As there was no difference in 3-year survival between native fistulas and grafts (63% versus 68%), both types were grouped together and compared to catheters. We examined the relationships between each indicator and survival in Cox proportional hazards models as follows: (a) unadjusted associations (i.e. hazard ratios), (b) associations adjusted for patient characteristics and (c) associations adjusted for other quality indicators and for patient characteristics. We also grouped the number of fulfilled quality indicators into three strata (0–2, 3 and $\geq$4), and constructed a comprehensive model that included this variable and all other relevant predictors. Transplanted patients were censored (i.e. removed from the analysis of mortality) at the time of transplantation, except for the last model (Table 3) where transplantation was used as a time-dependent variable. In the latter model, time before transplantation was used to compute the mortality risk of non-transplanted patients, and time after transplantation to compute mortality risk in transplanted patients. As low pre-dialysis systolic BP (SBP) in patients without any antihypertensive medications was associated with a poor 3-year survival, it was included in the Cox proportional hazards analysis.

Survival curves were obtained by the Kaplan–Meier method and compared with the log-rank test. All data analyses were performed using SPSS for Windows (version 11.0, Chicago, IL, USA).

Results

Data collection

Baseline data were obtained between March and June 2001 for all patients treated by HD ($n = 553$) in all 21 centres in western Switzerland from centre nurses and nephrologists. Three-year survival data were obtained for 541 (98%) patients.

Patient characteristics at baseline

Almost all patients (98%) were Caucasian; a slight majority was male and the mean age was 64 years (Table 1). Hypertensive nephropathy was the leading cause of ESRD (end-stage renal disease), and vascular disease was the most prevalent co-morbid condition. Diabetes was diagnosed as the main cause of ESRD in 15% of our patients but when included as a co-morbidity factor, it was present in nearly one-third of them. The mean modified Charlson index (including age) was 7.6 (SD3.1).

Two out of five patients were referred late for dialysis (Table 1). The median duration of renal replacement

Table 1. Demographic, clinical and treatment characteristics of HD patients in western Switzerland (March 2001)

Patients (*n*)	541
Age (year, mean ± SD)	64 ± 15
Patients >70 years old (%)	39.9
Male gender (%)	63
Late referral (%)	37.8
Causes of renal failure: (%)	
HTN	32
Diabetes (unique diagnosis)	14
Glomerulonephritis	14
Vasculitis	5
Interstitial nephritis	11
PCKD	13
Others	11
Smokers (%)	20
Physical disability (%)	17
Cerebrovascular/coronary/ heart/peripheral vascular disease (%)	53
Cancer (%)	14
Diabetes (%)	28
Body mass index between 20 and 25 (%)	48
Body mass index<20 (%)	14
Modified Charlson co-morbidity index (mean ± SD, range)	7.6 ± 3.1, 2–19
Patients wait-listed for transplantation (%)	21
Renal replacement therapy duration (year, median and IQR range)	3 (1–6.5)
Haemodialysis time (min, mean ± SD)	218 (37)
Biocompatible (synthetic) dialyser membranes (%)	90
Prevalence of high-flux membranes (%)	73
RhuEpo use (%)	90
Vitamin D use (%)	50
Calcium-based phosphate binders (%)	85
Aluminium salts (%)	17
ACE-inhibitors/angiotensin II antagonists use (%)	35
Beta-blockers use (%)	26
Native arteriovenous fistula/grafts/permanent catheters/temporary catheters (%)	58/22/13/7
sp*Kt*/*V* (mean ± SD)	1.37 ± 0.3
Haemoglobin (g/L) (mean ± SD)	118 ± 14
Phosphocalcic product ($mmol^2/L^2$) (mean ± SD)	3.9 ± 1.14
Serum albumin (g/L) (mean ± SD)	36.2 ± 5.9
HTN control (mean pre-dialysis BP<140/90) (%)	38

therapy was 3 years. The mean HD time was 218 min/session. Seventy-three percent of the patients had dialysis with high-flux membranes. Eighty percent had an AVF (Table 1). Mean *Kt*/*V*, albumin, haemoglobin and calcium–phosphate product are listed in Table 1.

Three-year survival

At 3 years of follow-up, 211 out of the 541 HD patients had died. Among the 108 patients on the waiting list, 63 were successfully transplanted. Three-year survival for transplanted patients, patients still wait-listed for transplantation and patients not wait-listed was 97% (68/70), 79% (30/38) and 54% (232/433), respectively.

Quality indicators and mortality

When looked at one by one, the only criterion of quality of care that remained highly significant for survival was the presence of a fistula, after adjusting for case-mix and other indicators of good clinical care (Table 2). In groups that fulfilled 0–2, 3 and >4 criteria, fistula prevalence was 49, 86 and 96%, respectively. In order to determine the impact of AVF, the Cox model with quality criteria (without fistula) categorized into 0–2-, 3- and 4–5-fulfilled indicators (reference) gives rather similar results when the fistula was added as an independent predictor. With fistula, the HR for 0–2- and 3-fulfilled criteria were 1.92 (95% CI 1.38–2.67, $P = 0.001$) and 1.09 (95% CI 0.77–1.55, $P = 0.62$), respectively. Without fistula, the HR for 0–2- and 3-fulfilled criteria were 1.73 (95% CI 1.19–2.52, $P = 0.004$) and 1.07 (95% CI 0.75–1.52, $P = 0.71$), respectively.

However, there was an increased survival with the attainment of indicators of good clinical care, as the 3-year rates were 50% (70/139), 62% (96/156) and 69% (165/240) in HD patients who had 0–2-, 3- and >4-attained indicators, respectively (Figure 1).

In the final multivariate analysis, the absence of transplantation, increased co-morbidity score (including age), absence of AVF, presence of SBP<110 mmHg and non-conformity to quality criteria remained independent predicting factors for death (Table 3). BMI between 26 and 29 was associated with a reduction in mortality (Table 3). We observed a trend for better survival with the use of high-flux membranes, which however did not reach statistical significance (Table 3). The adjusted effect of sub-optimal clinical quality (defined by <2-fulfilled quality criteria) was to increase mortality by 1.8-fold. This result differed somewhat by the Charlson score (CS 2–5: HR 2.60, 95% CI: 1.00–6.75, $P = 0.05$; CS 6–9: HR 1.63, 95% CI: 1.07–2.49,

Table 2. Relationships between quality of care indicators and survival of haemodialyzed patients in western Switzerland

Patients	Percentage	Unadjusted	Each quality indicator adjusted for case mix[a]	Each quality indicator adjusted for other indicators and case mix[a]
		HR (95% CI)	HR (95% CI)	HR (95% CI)
Albumin (g/L)				
>35	64	1.0	1.0	
30–35	24	0.71 (0.48–1.06)	1.11 (0.80–1.55)	1.06 (0.75–1.49)
<30	12	0.81 (0.35–0.81)	1.17 (0.78–1.74)	0.98 (0.65–1.50)
Haemoglobin (g/L)				
110–120 (or Hct 33–36%)	27	1.0	1.0	1.0
>120 (or Hct > 36%)	47	0.82 (0.56–1.19)	1.12 (0.79–1.59)	1.17 (0.82–1.66)
<110 (or Hct < 33%)	26	0.86 (0.62–1.20)	1.26 (0.86–1.84)	1.25 (0.86–1.84)
P × Ca product ($mmol^2/L^2$)	42	1.0	1.0	1.0
3.2–4.4	25	1.14 (0.82–1.59)	1.02 (0.72–1.44)	0.97 (0.69–1.38)
<3.2	33	1.28 (0.89–1.85)	0.93 (0.67–1.30)	
>4.4				0.93 (0.66–1.29)
SBP (mmHg)				
110–150	57	1.0	1.0	1.0
>150	39	1.15 (0.86–1.53)	0.98 (0.73–1.32)	0.94 (0.70–1.27)
<110	5	2.47 (1.43–4.24)	2.35 (1.36–4.05)	2.19 (1.22–3.92)
DBP (mmHg)				
70–90	64	1.0	1.0	1.0
>90	14	0.65 (0.48–0.90)	1.02 (0.66–1.59)	0.92 (0.58–1.46)
<70	22	0.66 (0.41–1.06)	1.57 (1.14–2.16)	1.62 (1.17–2.24)
sp*Kt*/*V*				
>1.2	76	1.0	1.0	1.0
1–1.2	16	1.41 (0.97–2.05)	1.17 (0.80–1.71)	1.17 (0.79–1.73)
<1	9	1.40 (0.87–2.24)	1.32 (0.82–2.12)	1.22 (0.75–1.98)
Presence of fistula	81	0.64 (0.46–0.87)	0.61 (0.44–0.84)	0.66 (0.47–0.92)
Quality of care indicators fulfilled:				
>4	45	1.0	1.0	1.0
3	29	1.29 (0.91–1.81)	1.14 (0.81–1.61)	1.29 (0.86–2.48)
0–2	26	1.92 (1.39–2.66)	1.80 (1.29–2.50)	2.81 (1.17–6.77)

[a]Modified Charlson's co-morbidity index, gender, body mass index and years of renal replacement therapy.

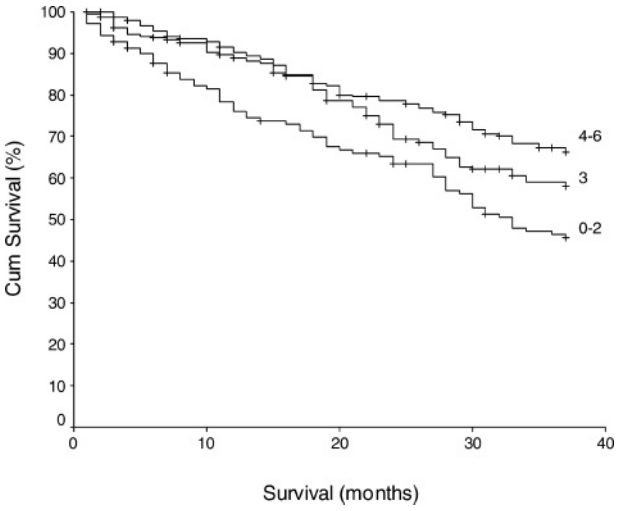

Fig. 1. Three-year survival curves according to the numbers of fulfilled indicators of quality of care in HD patients of western Switzerland (log rank 16.2, $P = 0.0003$).

$P = 0.02$; CS > 9: HR 1.90, CI: 1.21–2.98, $P = 0.005$) but these differences were not significant ($P = 0.66$).

Three-year survival curves established for groups of co-morbidity scores showed a decrease from 89% (score 2–5) to 36% (score>9) (Figure 2).

Discussion

Our study shows that good clinical care, assessed by clinical performance targets, is positively associated with 3-year survival in patients on HD. This effect is independent of patient characteristics, including their co-morbidities. Nearly half of our patients had ≥4-attained quality of care indicators and we could show that their death rate is significantly associated with decreasing number of quality of care indicators attained 3 years earlier (Figure 1 and Table 3).

Our results are in agreement with those of two recently published studies that studied the short-term impact of attaining similar clinical performance targets [9,10]. These targets were: haemoglobin (≥11 g/dL), dialysis dose ($Kt/V \geq 1.2$), albumin (≥4.0 g/dL) and presence of a native AVF. Calcium–phosphate product (≤4.4 $mmol^2/L^2$) was also considered as a clinical performance measure in the study of the CHOICE cohort where 668 incident HD patients had a prospective median follow-up of 2.8 years. At 6 months after enrolment in the study, attainment of each of the five targets studied was associated with a decreased mortality and morbidity [9]. This decrease was also proportional to the number of attached targets, irrespective of which target was met. Within the ESRD Clinical Performance Measures Project, 15 287 prevalent HD patients were studied and 1-year mortality decreased progressively from

Table 3. Univariate and multivariate analyses (with transplantation as a time-dependant variable) of predictive factors for death among haemodialyzed patients in western Switzerland (March 2001)

	Percentage	Univariate HR (95% CI)	*P*	Multivariate HR (95% CI)	*P*
Fulfilled indicators of quality of care:					
4–6	45	1.0		1.0	
3	29	1.30 (0.93–1.81)	0.13	1.10 (0.78–1.56)	
0–2	26	1.85 (1.34–2.56)	0.001	1.91 (1.38–2.65)	
No transplantation	13	10.40 (2.58–41.99)	0.001	7.27 (1.79–29.50)	0.006
Late referral	38	1.05 (0.79–1.38)	0.75	0.99 (0.75–1.33)	0.98
Male gender	63	1.14 (0.86–1.50)	0.36	1.24 (0.93–1.65)	0.15
BMI					
20–25	54	1.0		1.0	1.0
<20	11	1.15 (0.76–1.73)	0.52	0.98 (0.64–1.50)	0.93
26–29	21	0.72 (0.49–1.04)	0.08	0.61 (0.42–0.90)	0.60
>29	14	0.91 (0.61–1.38)	0.66	0.89 (0.58–1.37)	0.1
Modified Charlson's score					
2–5	24	1.0	1.0		1.0
6–9	49	3.45 (2.07–5.77)	0.001	3.38 (1.99–5.71)	0.001
>9	27	7.06 (4.21–11.86)	0.001	7.19 (4.20–12.29)	0.001
RRT (years)		0.99 (0.98–1.02)	0.84	1.01 (0.99–1.04)	0.28
Low pre-dialysis SBP (<110 mmHg)	5	2.24 (1.33–3.80)	0.003	2.44 (1.43–4.16)	0.001
High flux (versus low flux)	73	0.68 (0.51–0.91)	0.009	0.79 (0.59–1.06)	0.12

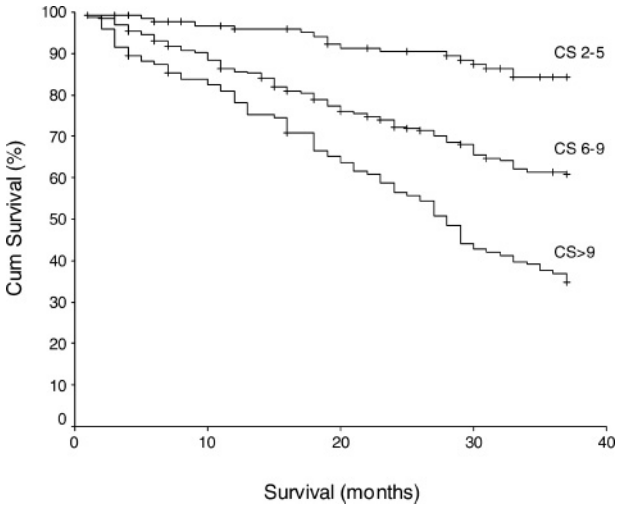

Fig. 2. Three-year survival curves according to modified Charlson's co-morbidity scores in HD patients of western Switzerland (log rank 63.7, $P < 0.001$).

29 to 7% with an additional attainment of 0–4 targets [10]. Partial adjustment was made for patients' co-morbidities and follow-up was relatively short in this study [10]. However, our results confirmed that attainment of clinical performance targets in prevalent patients after adjustment for their co-morbidities was also associated with a decrease in mortality. The presence of fistula was the only isolated indicator of good clinical care that was associated with a significant decline in the 3-year mortality (Table 2). Among the different types of vascular accesses, AVF is known to have fewer complications than grafts or tunnelled permanent catheters. Nevertheless, the latter are increasingly employed because of an aging dialysis population with less usable vessels and more at risk of AVF primary failure. A 50% higher mortality was found in incident patients not dialyzed with AVF [13].

More than one-third of our patients were referred within <1 month of starting dialysis. Although late referral in our population was not associated with a decreasing 3-year survival, this late referral has been associated with increasing catheter use [14]. Only upstream strategies aimed at identifying the candidates earlier so that their venous network could be spared will maximize the number of patients with AVF.

Of the other factors associated with death, absence of transplantation, overweight, low pre-dialysis BP and co-morbidities (including age) remained significant predictive factors of death in HD patients. The positive impact of transplantation in our patients is in agreement with what is currently found in the medical literature [15,16].

Overweight HD patients have been found to have a greater survival than their leaner counterparts [7,17] and our patients with a BMI between 26 and 29 had a 3-year mortality that was 39% lower than their counterparts with a BMI ranging between 20 and 25. A higher BMI was, however, not statistically significant in our multivariate analysis. Though we cannot exclude a type II error, it is likely that compared to a North American HD population, there is a narrower range of BMI values in our population with 73% of our patients between 20 and 29.

Hypertension is one of the major cardiovascular risk factors, but low pre-dialysis BP predicts increased mortality in observational studies [18,19]. As with obesity, the physiopathology underlying the association between mortality and low BP remains elusive, although this changes over time with low BP being especially harmful within the first 2 years of dialysis and high BP after 2 years [18,20]. Low mean arterial pressure was a strong predictor of death in our population. Although we cannot exclude that the patients with low BP were sicker, their demographic characteristics and mean Charlson score were not different from patients with higher pre-dialysis BP (data not shown). Achieving dry weight in patients with low BP may be difficult and these patients are more prone to dialysis-associated hypotension

with subsequent increasing morbidity. The physiopathology of the negative impact of low BP in HD patients needs to be better understood, so that a more specific therapeutic approach can be devised.

A low serum albumin is a marker of poor clinical condition and/or poor nutritional status and is associated with subsequent increasing mortality in HD patients [8,21]. Adjustment for co-morbidities other than diabetes was not done in these previous studies. In our patients, serum albumin <30 g/L was not significantly associated with mortality after adjustment for other risk factors. Conflicting results have been found in previous studies on the beneficial impact of using high-flux membranes. We found a beneficial effect of high-flux membranes that just fell short of statistical significance. A similar effect was observed among French patients, whose mean dialysis duration was 102 months; those treated with high-flux membranes experienced a 40% reduction in the 2-year mortality [22]. In contrast, no difference of mortality between patients treated either by low-flux HD or by high-flux HD has been reported in the DOPPS study [23]. Use of high-flux membranes was not found to have a significant impact on mortality except for patients with transplantation vintage >3.7 years of dialysis in the HEMO study [24].

Associated co-morbidities heavily determine the fate of our patients [21] and measuring them is of importance, as this treatment is lifesaving but very expensive.

The Charlson co-morbidity index has been validated in the dialysis population with some minor modifications [11,16,25]. In our patients, duration of survival was inversely related to their Charlson scores (Figure 2). Though co-morbidities do not fully explain the difference in mortality among the American, European and Japanese patients and their impact after adjustment for age, gender and race is lower than expected [26,27], a simple and easy-to-use co-morbidity score could be useful for clinical decision-making. Its use may help to determine a successful long-term implementation of dialysis especially for elderly patients, whose number has been rising in the past decade [28]. However, the Charlson score needs to be validated first in an incident HD population in the elderly prior to the generalization of its use.

Our study has some limitations. This longitudinal study did not have serial repeated measurements and it is likely that our indicators of quality of care and some dialysis-related characteristics such as membranes or weekly dialysis time for patients treated by chronic HD may have changed throughout the follow-up time. This is an observational study allowing us to measure associations between clinical factors and survival, but which cannot demonstrate any causal relationship. Our patients had in this survey an unadjusted 3-year survival rate of 61%, which is relatively similar to the 3-year survival rate of 65% for incident HD patients reported in the annual report 2002 ERA–EDTA registry [1]. However, there was a predominance of Caucasians in our population and an extrapolation of our results to multiracial societies other than European may not be possible.

In summary, our results show that the attainment of targets set by the guidelines to improve quality of care increase survival in our HD patients after adjustment for case mix. Importantly, the use of a catheter, as opposed to a fistula, was associated with shorter survival. Similarly, low pre-dialysis BP also predicted shorter survival. These results suggest that changes to pre-dialysis care and dialytic procedures, such as shifting to short daily dialysis or night-long dialysis in order to overcome hypotension-related dialysis difficulties, may ultimately improve survival.

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Conflict of interest statement. None declared.

Appendix

The Western Switzerland Dialysis Study Group

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