RESEARCH ARTICLE

Improvements in six aspects of quality of care of incident hemodialysis patients – a real-world experience

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Abstract

Background: The transition from chronic kidney disease stage 5 to initiation of hemodialysis has gained increased attention in recent years as this period is one of high risk for patients with an annual mortality rate exceeding 20%. Morbidity and mortality in incident hemodialysis patients are partially attributed to failure to attain guideline-based targets. This study focuses on improvements in six aspects of quality of dialysis care (adequacy, anemia, nutrition, chronic kidney disease-mineral bone disorder (CKD-MBD), blood pressure and vascular access) aligning with KDIGO guidelines, during the first 6 months of hemodialysis.

Methods: We analyzed patient demographics, practice patterns and laboratory data in all 3 462 patients (mean age 65.9 years, 41% females) on hemodialysis (incident <90 days on hemodialysis, n=603, prevalent ≥90 days on hemodialysis, mean 55 months, n=2 859) from all 56 DaVita centers in Poland (51 centers) and Portugal (5 centers). 80% of patients had hemodialysis and 20% hemodiafiltration. Statistical analyses included unpaired and paired Students t-test, Chi-2 analyses, McNemar test and logistic regression analysis.

Results: Incident patients had lower Kt/V (1.4 vs 1.7, p<0.001), lower serum albumin (37 vs 40 g/l, p=0.001), lower Hb (9.9 vs 11.0 g/dl, p<0.001), lower TSAT (26 vs 31%, p<0.001), lower iPTH (372 vs 496 pg/ml, p<0.001), more often a central venous catheter (68 vs 26%, p<0.001), less often an AV fistula (34 vs 70%, p<0.001) compared with all prevalent patients. Significantly more prevalent patients achieved international treatment targets.

Improvements in quality of care was also analyzed in a subgroup of 258 incident patients who were followed prospectively for 6 months. We observed significant improvements in Kt/V (p<0.001), albumin (p<0.001), Hb (p<0.001), transferrin saturation (TSAT, p<0.001), iPTH (p=0.005) and an increased use of AV fistula (p<0.001). Furthermore, logistic regression analyses identified treatment time and TSAT as major factors influencing the attainment of adequacy and anemia treatment targets.

Conclusion: This large real-world European multicenter analysis of representative incident hemodialysis patients indicates that the use of medical protocols and medical targets assures significant improvements in quality of care, which may correspond to better outcomes. A selection bias of survivors with less comorbidities in prevalent patients may have influenced the results.

Background

The transition from chronic kidney disease stage 5 to initiation of hemodialysis has received increased attention in recent years, as this period is one of high vulnerability
for patients, with an annual mortality rate exceeding 20% [1–3]. The increased risk of mortality in incident patients is associated with the presence of risk factors such as the quality of pre-dialysis care, age, gender and concurrent comorbidities, for instance diabetes mellitus, cardiovascular and nutritional status [1–3].

Over the past decades, there has been a tendency towards commencement of hemodialysis at higher levels of residual kidney function [4–7]. Definitive clinical trials of early versus later timed hemodialysis initiation have been difficult to conduct, partly due to the unpredictable clinical course that often accompanies deterioration in renal function. Still after the Initiating Dialysis Early and Late (IDEAL) trial [8], substantial debate continues regarding the impact on mortality and outcomes of initiating dialysis early versus late [4–7].

Previous studies have shown that the risk of early mortality after starting hemodialysis is independently associated with failure to attain guideline-based international treatment targets for dialysis adequacy (dose of hemodialysis, Kt/V and urea reduction ratio, URR), nutrition (serum albumin), renal anemia (hemoglobin and iron levels), CKD-MBD (serum phosphorus, calcium, PTH) and bone density [9–12]. Early mortality risk is also related to features of predialysis care which includes delayed referral to nephrology services and having an arterio-venous fistula or a central venous catheter as primary vascular access when commencing hemodialysis [13–15].

The importance of providing individual patients adequate quality of care before and following start of hemodialysis is well recognized. Identifying modifiable treatment factors that are associated with the heightened risk of morbidity and mortality during this early dialysis period is thus essential.

This large European multicenter study included all patients treated at all DaVita dialysis facilities in Poland (51 centers) and Portugal (5 centers). Eighty percent of patients had been treated by hemodialysis and 20% hemodiafiltration. Since all patients treated at all dialysis facilities were included in the analysis, this cohort represented a “real-world” clinical experience.

In all facilities, blood samples were collected monthly or quarterly in accordance with international dialysis guidelines (European Renal Best Practice (ERBG) guidelines and K/DOQI (Kidney Disease Outcomes Quality Initiative) guidelines). All clinics followed medical protocols and aimed the same medical targets being representative for abovementioned guidelines. Patient and treatment characteristics and biochemical data were collected during routine hemodialysis practice. Demographic and laboratory data, as well as information on practices, were analyzed in all patients in the same month of 2019. Laboratory analyses were made at local laboratories with validated and recommended procedures. Kt/V was assessed as single pool Kt/V (spKt/V) and intact PTH (iPTH) was measured. All patients treated with erythropoiesis stimulating agents (ESA) had erythropoietin alpha or beta. The erythropoiesis-stimulating agent resistance index (ERI) was defined as the weight-adjusted weekly ESA dose divided by the hemoglobin value (IU/week/kg/Hb).

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics version 25. All values are presented as mean or standard deviation (SD) or proportions and counts. We compared all incident to all prevalent patients (unpaired Students t-test and Chi-2 analyses) and in addition analyzed improvements in six aspects of quality of dialysis care in a subgroup of patients who were followed prospectively for 6 months (paired Students t-test and McNemar analyses). Logistic regression analysis was done to identify factors significantly influencing the achievement of treatment targets. A p-value <0.05 was considered statistically significant.

Results

Incident vs prevalent patients on hemodialysis

We analyzed six aspects of quality of hemodialysis care (adequacy, nutrition, renal anemia, CKD-MBD, blood pressure control and vascular access) in 603 patients on hemodialysis for less than 90 days (incident patients) and compared the results to 2 859 patients who had been on maintenance hemodialysis for more than 90 days (prevalent patients, Table 1). There were no significant differences in age, gender or Charlson comorbidity index between the groups (Table 1). Diabetes was more common in prevalent (27%) than in incident patients (23%).

Methods

Patients and data collection

We analyzed patient demographics, hemodialysis practice patterns and laboratory data from all 3 462 patients (mean age 65.9 years, 41% females) on hemodialysis (incident <90 days on hemodialysis, n=603, prevalent ≥90 days on hemodialysis, mean hemodialysis vintage 55 months, n=2 859 patients) from all 56 DaVita hemodialysis facilities in Poland (51 centers) and Portugal (5 centers). Eighty percent of patients had been treated by hemodialysis and 20% hemodiafiltration.
In addition, more prevalent patients had been treated by hemodiafiltration (22% vs 11%). Prevalent patients had higher Kt/V (1.7 vs 1.4, \( p<0.001 \)), longer treatment time, higher blood flow rate and consequently a higher treated blood volume per session than incident patients (\( p<0.001 \) for all comparisons, Table 1). Furthermore, serum albumin and potassium were higher (\( p<0.001 \)) in prevalent patients, maybe indicating a more favorable alimentary status. In terms of anemia control both all prevalent patients, and

| Aspects of quality of care | Incident patients \( n=603 \) | Prevalent patients \( n=2859 \) | \( p^* \) |
|---------------------------|-----------------------------|-----------------------------|-----------|
| Age (years)               | 66.3 (14.6)                 | 67.1 (14.2)                 | NS        |
| Charlson comorbidity index| 6.9 (2.9)                   | 6.9 (2.9)                   | NS        |
| Adequacy                  |                             |                             |           |
| Weekly treatment time (min)| 677 (116)                  | 721 (77)                    | <0.001    |
| Blood flow rate (ml/min)  | 295 (65)                    | 351 (77)                    | <0.001    |
| Treated blood volume (l/kg)| 1.0 (0.3)                   | 1.2 (0.7)                   | <0.001    |
| HD treatments/week        | 3.0 (0.4)                   | 3.0 (0.3)                   | NS        |
| Kt/V                      | 1.4 (0.4)                   | 1.7 (0.4)                   | <0.001    |
| URR (%)                   | 66 (16)                     | 74 (10)                     | <0.001    |
| Potassium (mmol/l)        | 4.8 (0.7)                   | 5.2 (1.0)                   | <0.001    |
| Nutrition                 |                             |                             |           |
| Body weight               | 70.8 (20)                   | 72.4 (17)                   | NS        |
| BMI (kg/m\(^2\))          | 25.9 (0.9)                  | 26.3 (6.5)                  | NS        |
| Albumin (g/l)             | 37.4 (19.5)                 | 40.7 (21.8)                 | 0.001     |
| Anemia                    |                             |                             |           |
| Hb (g/dl) all pts         | 9.9 (1.6)                   | 11.0 (1.3)                  | <0.001    |
| Hb (g/dl) on ESA           | 9.8 (1.5)                   | 10.8 (1.2)                  | <0.001    |
| TSAT (%)                  | 26 (12)                     | 31 (14)                     | <0.001    |
| Ferritin (μg/l)           | 305 (291)                   | 540 (542)                   | <0.001    |
| Weekly ESA dose (IU/week) | 5470 (4440)                 | 4982 (3640)                 | <0.05     |
| ERI (ESA U/week/kg/Hb)    | 8.5 (8.4)                   | 7.0 (6.3)                   | <0.001    |
| CKD MBD                   |                             |                             |           |
| Phosphorus (mg/dl)        | 4.8 (1.6)                   | 5.0 (1.6)                   | NS        |
| Calcium (mg/dl)           | 8.7 (2.2)                   | 8.8 (1.6)                   | NS        |
| iPTH (pg/ml)              | 372 (298)                   | 496 (448)                   | <0.001    |
| Blood pressure            |                             |                             |           |
| MAP (mm Hg)               | 95 (12)                     | 94 (14)                     | NS        |
| IDBWG (%)                 | 1.6 (4.6)                   | 2.6 (1.5)                   | <0.001    |
| UF volume (ml/session)    | 1687 (963)                  | 2259 (1008)                 | <0.001    |
| Vascular access           |                             |                             |           |
| AV fistula (%)            | 32                          | 70                          | <0.001    |
| AV graft (%)              | 1                           | 4                           | <0.001    |
| CVC (%)                   | 68                          | 26                          | <0.001    |
| Sex (% female)            | 42                          | 41                          | NS        |
| Age ≥70 years (%)         | 46                          | 47                          | NS        |
| Diabetes mellitus (%)     | 23                          | 27                          | <0.05     |
| Hemodiafiltration (%)     | 11                          | 22                          | <0.001    |

Abbreviations: HD hemodialysis, URR urea reduction ratio, BMI body mass index, ESA erythropoiesis stimulating agent, TSAT transferrin saturation, ERI erythropoietin resistance index, iPTH intact parathyroid hormone, MAP mean arterial pressure, IDBWG interdialytic body weight gain, AV arteriovenous, CVC central vascular catheter

\(^*\) Students t-test and Chi-square analysis for continuous numbers (mean and SD) and percentages respectively

\( p<0.05 \). In addition, more prevalent patients had been treated by hemodiafiltration (22% vs 11%). Prevalent patients had higher Kt/V (1.7 vs 1.4, \( p<0.001 \)), longer treatment time, higher blood flow rate and consequently a higher treated blood volume per session than incident patients (\( p<0.001 \) for all comparisons, Table 1). Furthermore, serum albumin and potassium were higher (\( p<0.001 \)) in prevalent patients, maybe indicating a more favorable alimentary status. In terms of anemia control both all prevalent patients, and
the subgroup of patients on ESA, had higher Hb, higher TSAT and ferritin than incident patients \((p<0.001\) for all comparisons, Table 1). Furthermore, the weekly ESA dose was lower and ERI lower in prevalent patients \((p<0.05\) and \(p<0.001\) respectively). There were no significant differences in calcium and phosphorus concentrations between the groups, but iPTH was higher in prevalent compared to incident patients \((p<0.001)\). Interdialytic body weight gain (IDWG) and ultrafiltration (UF) volume were both higher in prevalent patients \((p<0.001)\) but MAP was similar in both groups. Prevalent patients more often had an AV fistula (70%) than incident patients (32%, \(p<0.001\)) and consequently the use of a central venous catheter was higher in incident (68%) compared to prevalent patients (26%, \(p<0.001\), Table 1).

### Achievement of treatment targets

The attainment of treatment targets in international guidelines, in incident and prevalent patients is presented in Table 2. Significantly more prevalent hemodialysis patients had Kt/V \(\geq 1.2\), serum albumin \(\geq 40\) g/l, Hb 10-12 g/dl, TSAT \(\geq 20\%\) and ferritin \(\geq 200\) μg/l \((p<0.001\) for all comparisons). We observed a small but significant difference in the control of iPTH between groups (Table 2).

### Improvements in quality of hemodialysis care in patients after 6 months of care

Improvements in six aspects of quality of hemodialysis care in 258 incident patients is presented in Table 3. We observed a significant improvement in Kt/V, increased treatment time, blood flow rate and treated blood volume over time \((p<0.001\) for all comparisons) in incident patients vs the same patients after 6 months of treatment at DaVita facilities. Hb increased with improved control of iron parameters \((p<0.001)\) and a concomitant reduction of ESA dose \((p=0.09)\) in combination with lower ERI \((p=0.05)\). Small and statistically significant changes in serum calcium and iPTH were observed. Significantly more patients had an AV fistula after 6 months (55%, \(p<0.001\)) and fewer patients had a central venous catheter (42%, \(p<0.001\)) compared to incident patients.

### Improvements in the achievement of treatment targets over 6 months

We observed a significant improvement in the attainment of international treatment targets in terms of dialysis adequacy \((p<0.001)\), nutrition \((p<0.001)\) and control of renal anemia \((p<0.001\) both for all patients, and for patients on ESA) in patients treated for 6 months compared to the same patients during their first 90 days of hemodialysis care (Table 4).

| Table 2 | Achievement of international treatment targets in 603 incident patients (<90 days on hemodialysis) and 2859 prevalent patients (>90 days on maintenance hemodialysis) |
|---------------------|---------------------------------|----------------------|----------------------|
| Aspects of quality of care | Incident patients \(n=603\) | Prevalent patients \(n=2859\) | \(p^*\) | Chi square |
| Adequacy | | | | | |
| Weekly treatment time \(\geq 720\) min | 68 | 87 | \(<0.001\) | |
| Blood flow rate \(\geq 300\) ml/min | 67 | 96 | \(<0.001\) | |
| Kt/V \(\geq 1.2\) | 69 | 94 | \(<0.001\) | |
| Treated blood volume \(\geq 1\) l/kg | 42 | 75 | \(<0.001\) | |
| Nutrition | | | | | |
| Albumin \(< 40\) g/l | 71 | 47 | | |
| \(\geq 40\) g/l | 29 | 53 | \(<0.001\) | |
| Anemia | | | | | |
| Hb \(< 10\) mg/dl | 52 | 16 | | |
| Hb 10-12 mg/dl | 41 | 67 | \(<0.001\) | |
| Hb \(> 12\) mg/dl | 7 | 17 | | |
| TSAT \(\geq 20\%\) | 66 | 82 | \(<0.001\) | |
| Ferritin \(\geq 200\) μg/l | 55 | 81 | \(<0.001\) | |
| CKD MBD | | | | | |
| PTH \(< 150\) pg/ml | 21 | 16 | | |
| PTH 150-600 pg/ml | 62 | 57 | \(<0.001\) | |
| PTH \(> 600\) pg/ml | 18 | 27 | | |

* Chi-square analysis
Logistic regression analyses of parameters affecting treatment targets

Table 5 shows logistic regression analyses of parameters influencing hemodialysis adequacy (Table 5A), serum albumin (Table 5B), anemia (Table 5C) and CKD MBD (Table 5D). Women, patients with an increase in treatment time during the six prospective months (Δ treatment time) and patients with a higher BMI were more likely to attain a Kt/V ≥ 1.2 (Table 5A). Patients with low Charlson comorbidity index were more likely to reach a serum albumin ≥ 40 g/l (Table 5B) and patients with an increase in TSAT over 6 months (ΔTSAT) had significantly higher odds ratio to have a Hb between 10-12 g/dl (Table 5C).

Discussion

The annual mortality rate for patients on maintenance hemodialysis is several times higher than that of the general population [1, 16]. Compared to prevalent patients, incident hemodialysis patients experience...
an even higher risk of mortality within the first few months after initiation of dialysis [2, 3, 16]. Identifying practices and modifiable treatment features that are associated with higher risk of death during this early dialysis period is thus of importance. Some argue that this high-risk period should be one important focus for future clinical investigations [17, 18]. It is important to explore differences in hemodialysis practices and outcomes and to identify optimal treatment approaches to improve early patient survival.

In the present large European multicenter analysis of incident hemodialysis patients, we demonstrate that the use of medical protocols and consistent monthly follow up of laboratory and medical targets to align with recommendations in international guidelines, assures significant improvements in quality of care in many clinical areas, which may correspond to better outcomes. In the present large European multicenter analysis of incident hemodialysis patients, we demonstrate that the use of medical protocols and consistent monthly follow up of laboratory and medical targets to align with recommendations in international guidelines, assures significant improvements in quality of care in many clinical areas, which may correspond to better outcomes.

Table 4 Improvement in the achievement of international treatment targets in 258 incident hemodialysis patients (<90 days on hemodialysis) vs the same patients after 6 months of hemodialysis

| Aspects of quality of care | Incident patients (<90 days) n=258 | Prevalent patients (>6 months) n=258 | p* |
|---------------------------|-----------------------------------|-----------------------------------|----|
| Adequacy                  |                                    |                                   |    |
| Weekly treatment time ≥720 min | 18                           | 28                           | <0.001 |
| Blood flow rate ≥300 ml/min | 44                           | 71                           | <0.001 |
| Kt/V >1.2                 | 69                           | 84                           | <0.001 |
| Treated blood volume ≥1 l/kg | 42                           | 67                           | <0.001 |
| Nutrition                 |                                    |                                   |    |
| Albumin ≥40 g/l           | 28                           | 48                           | <0.001 |
| Anemia                    |                                    |                                   |    |
| Hb <10 mg/dl              | 53                           | 26                           | <0.001 |
| Hb 10-12 mg/dl            | 40                           | 54                           | <0.001 |
| Hb >12 mg/dl              | 7                            | 19                           | <0.001 |
| TSAT ≥20%                 | 67                           | 72                           | 0.015 |
| Ferritin ≥200 μg/l        | 58                           | 72                           | 0.001 |
| CKD MBD                   |                                    |                                   |    |
| Phosphorus ≤5.5 mg/dl     | 26                           | 30                           | NS |
| Calcium ≤10.2 mg/dl       | 98                           | 95                           | NS |
| PTH 150-600 pg/ml         | 61                           | 60                           | NS |

In the field of chronic kidney disease and dialysis, international clinical practice guidelines have been developed and implemented to improve patient care and outcomes [19–21]. The National Kidney Foundation manages Kidney Disease Outcomes Quality Initiative (KDOQI) [19]. The KDIGO initiative [20] is aimed at improving the care and outcomes of kidney disease patients worldwide, through the development and implementation of global clinical practice guidelines. In parallel, the European Renal Association and the European Dialysis and Transplant Association (ERA EDTA) have initiated the ERBP initiative [21].

The attainment of five guideline targets for hemodialysis patients in European countries (hypertension, anemia, dyslipidemia, metabolic acidosis and CKD-MBD) has recently been audited and revealed to be low overall and far from complete, with substantial differences between countries, which emphasizes the importance of optimizing the care of hemodialysis patients in Europe [22–24]. The EURODOPPS consortium calculated the risk of death and hospital admissions as a function of the simultaneous attainment of clinical guideline targets for hypertension, anemia and CKD-MBD in a large cohort of European dialysis patients [24]. Low attainment of treatment targets was associated with higher risk of mortality, and high fulfilment was independently associated with lower mortality. This association increased gradually as a function of degree of target attainment [24]. Moreover, the risk of early death after starting hemodialysis has been shown to be independently linked with failure to accomplish guideline-based treatment targets for dose of hemodialysis, serum albumin, type of vascular access and level of hemoglobin [10–12].

An analysis of patients on maintenance hemodialysis demonstrated that survival was significantly associated with higher adherence to the clinical targets specified by the KDOQI guidelines [11]. In addition, the dialysis
unit practice score, developed as part of the international Dialysis Outcomes and Practice Patterns Study (DOPPS), was strongly linked to outcomes [10–12]. Simultaneous achievement of dialysis dosage, anemia, and serum albumin targets was associated with a marked reduction in mortality and other studies extend these observations to include serum calcium, phosphorus, and PTH targets [25–29]. Patients increasingly meeting more quality goals also report better quality of life [30].

In the present study, both Kt/V and URR were significantly higher in prevalent hemodialysis patients, who had been surveilled in the systematic quality program to attain treatment targets, than in incident patients, which is a consequence of a significant increase in prescribed treatment time, blood flow rate and consequently a higher treated blood volume per session. Logistic regression analysis identified longer treatment time as the most important feature affecting attainment of target dialysis dose, measured as Kt/V.

Previous studies have demonstrated favorable clinical outcomes with longer treatment time and shown associations of longer treatment with better anemia, phosphorus and blood pressure control as well as improved survival among hemodialysis patients [31].

One clinically important finding is the significant improvement in serum albumin from 37 g/l to 41 g/l in patients on hemodialysis for more than three and six months respectively, compared to incident patients. Serum albumin is a strong prognostic factor for adverse outcomes in adults on hemodialysis. Hypoalbuminemia

| Odds ratio (CI) | p       |
|----------------|---------|
| A. Logistic regression analysis on hemodialysis adequacy (Kt/V ≥1.2) |         |
| Age (years)    | 1.00 (0.98-1.03) | 0.863 |
| Gender (female)| 0.42 (0.20-0.910) | 0.028 |
| Charlson comorbidity index | 0.96 (0.843-1.085) | 0.484 |
| BMI (kg/m²)    | 1.08 (1.02-1.14) | 0.010 |
| ∆Treatment time (min per week) | 1.01 (1.00-1.01) | 0.003 |
| ∆Blood flow (ml/min) | 1.01 (0.99-1.01) | 0.089 |
| B. Logistic regression analysis on nutrition (albumin ≥40 g/l) |         |
| Age (years)    | 0.99 (0.97-1.01) | 0.261 |
| Gender (female)| 0.70 (0.37-1.31) | 0.267 |
| Charlson comorbidity index | 0.88 (0.776-0.999) | 0.049 |
| BMI (kg/m²)    | 0.98 (0.94-1.03) | 0.478 |
| ∆Treatment time (min per week) | 1.00 (0.99-1.003) | 0.897 |
| ∆Blood flow (ml/min) | 0.99 (0.99-1.001) | 0.075 |
| ∆Kt/V | 1.71 (0.81-3.62) | 0.161 |
| C. Logistic regression analysis on anemia (Hb 10-12 g/dl) |         |
| Age (years)    | 1.003 (0.98-1.02) | 0.762 |
| Gender (female)| 1.24 (0.69-2.60) | 0.474 |
| Charlson comorbidity index | 1.071 (0.959-1.196) | 0.225 |
| ∆Blood flow (ml/min) | 1.003 (0.998-1.008) | 0.223 |
| ∆Kt/V | 1.08 (0.53-2.20) | 0.828 |
| ∆TSAT (%) | 1.03 (1.01-1.05) | 0.017 |
| ∆Ferritin (μg/l) | 0.99 (0.998-1.000) | 0.041 |
| D. Logistic regression analysis on CKD-MBD (iPTH 150-600 pg/ml) |         |
| Age (years)    | 1.002 (0.99-1.03) | 0.869 |
| Gender (female)| 0.98 (0.49-1.96) | 0.956 |
| Charlson comorbidity index | 1.017 (0.91-1.137) | 0.767 |
| ∆Kt/V | 1.10 (0.49-2.50) | 0.817 |
| ∆Treatment time (min per week) | 1.001 (0.998-1.004) | 0.403 |
| ∆Phosphorus (mg/dl) | 0.98 (0.82-1.18) | 0.826 |
| ∆Calcium (mg/dl) | 0.91 (0.73-1.39) | 0.408 |
may reflect poor nutrition or presence of inflammation and predicts hospitalization and mortality. Protein energy wasting is closely associated with malnutrition, inflammation and arteriosclerosis and serum albumin is an established surrogate biomarker [32]. This accords with our observation in the present study, showing that patients with low Charlson comorbidity index were more likely to attain this treatment target.

Patients in the current study showed improved anemia control with significantly higher Hb, TSAT and ferritin in combination with significantly lower doses of ESA and lower ERI in prevalent patients compared to incident patients. In addition, the attainment of anemia guidelines was significantly better in prevalent patients. Anemia is associated with morbidity and mortality in chronic kidney disease. The use of ESA is associated with improved functional status, quality of life, and lower requirements for blood transfusion. At the same time, ESAs constitute the largest share of the costs of injectable drugs used in patients on dialysis in many countries. High doses of ESA in patients with comorbidities have however been associated with worse outcomes in randomized controlled trials [33, 34]. The optimal iron management practice to support ESA therapy remains uncertain. In patients on hemodialysis, a high-dose intravenous iron regimen administered proactively was superior to a low-dose regimen administered reactively and not only resulted in lower doses of ESA being administered but also in reduction of cardiovascular end points (non-fatal myocardial infarction, non-fatal stroke and heart failure hospitalization) [35].

In terms of achieving CKD-MBD guidelines targets for PTH in the present study, we observed a significant switch with fewer prevalent patients having a PTH <150 pg/ml and more prevalent patients having PTH >600 pg/ml. Abnormalities in serum calcium, phosphorus, and PTH concentrations are common in patients with chronic kidney disease and have been associated with increased cardiovascular calcification, arterial dysfunction, morbidity and mortality [25–27]. However, no clinical trials have been conducted to clearly identify categories of calcium, phosphorus, and PTH levels associated with the lowest mortality risk. A PTH>600 pg/ml has been associated with adverse clinical outcomes in most published studies and patients with higher PTH had longer duration of dialysis [25–27]. We do not have information on the use of phosphate binders, vitamin D or cinacalcet in the current study.

In the present study, blood pressure was similar in prevalent and incident patients, but IDWG was significantly higher in prevalent patients, potentially reflecting loss of residual urine output between zero and 90 days of hemodialysis. Observational studies have provided conflicting data on the relationships between blood pressure and mortality among hemodialysis patients. Some studies suggest elevated mortality rates at low and not high, blood pressure and other studies have identified a U-shaped correlation between blood pressure and mortality in dialysis [36].

The exact relationship between IDWG and blood pressure control is incompletely characterized. In prevalent hemodialysis subjects, increasing percentage of IDWG is associated with increases in predialysis blood pressure [37].

In this study, we demonstrate a significant increase in the use of AV fistula in prevalent patients (70%) compared to incident patients (32%). Importantly, the use of a central venous catheter for hemodialysis decreased significantly in prevalent patients. The National Kidney Foundation (NKF) recommends an AV fistula as the optimal vascular access due to its higher long-standing patency and lower intervention rate than other vascular access types, which translates into benefits in morbidity and mortality. Hemodialysis guidelines recommend placement of an AV fistula at least six months before the predicted start of hemodialysis, but despite these guidelines, in 2015, 80% of patients in the United States started hemodialysis with a central venous catheter, only 17% with an AV fistula, and only 3% with an AV graft [38].

Satisfying guidelines for multiple parameters is a therapeutic challenge. We observed significant increases in guideline adherence for adequacy, nutrition and vascular access over time. This may reflect in part improved clinical practice patterns and in part survivor bias. Clinical practice patterns associated with increased guideline adherence should be identified and implemented by all providers of dialysis care. Meeting such targets should be viewed as routine and a minimum standard of care for all new patients on dialysis and a complement to personalized, holistic and multidisciplinary team led care approach to individual patients.

The strength of this study is that it included all prevalent patients at all hemodialysis facilities in DaVita centers in Poland and Portugal, thus representing a real-world experience. This study has limitations. We do not have data on hard outcomes, such as hospitalizations and mortality and limited information of prescribed medication. Furthermore, we do not know to what extent incident dialysis patients are intentionally prescribed for example lower treatment times and blood flow rates, resulting in lower Kt/V, due to presence of significant residual kidney function in the first months after start of dialysis. We do not have robust data on the number of incident patients that were transplanted or died during the observation period. In addition, prevalent patients may be a selected group of more healthy survivors and
potentially more compliant. Also, in the subgroup of 258 patients followed over time there may be a selection of individuals with lower risk.

Conclusion

This large European multicenter analysis of incident hemodialysis patients indicates that the use of medical protocols to achieve important clinical targets assures significant improvements in quality of care, which may correspond to better patient outcomes.

Abbreviations

BMI: Body mass index; ESA: Erythropoiesis stimulating agent; ESRD: End-stage renal disease; Hb: Hemoglobin; IV: Intravenous; PTH: Parathyroid hormone; SC: Subcutaneous; TSAT: Transferrin saturation.

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Authors’ contributions

MD contributed to the design of the study, acquisition of clinical data, interpretation of results, writing and revision of the manuscript. JJF contributed to the acquisition of clinical data, interpretation of results and revision of the manuscript. FS contributed to the acquisition of clinical data and interpretation of results. PD contributed to the acquisition of clinical data and revision of the manuscript. WK contributed to the acquisition of clinical data, interpretation of results and revision of the manuscript. SB contributed to the design of the study, acquisition of clinical data, interpretation of results and revision of the manuscript. SJ contributed to the design of the study, acquisition of clinical data, interpretation of results and revision of the manuscript and as corresponding author. All authors approved the final version of the manuscript for submission. Statistical analyses were performed by SHJ and FJK (see acknowledgement).

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the regional ethics committee at the Karolinska Institutet, Stockholm, Sweden (Regionala Ethikprovinskommittén Stockholm, EPN). All clinical and laboratory patient data were abstracted in deidentified form from the respective country. All statistical analyses were performed at the Department of Clinical Sciences at Karolinska Institutet, Stockholm, Sweden. Data used in this study were derived from the proprietary electronic health records database of a large dialysis provider and are not publicly available.

Consent for publication

Not applicable

Competing interests

WK has received speaker fees from Boehringer Ingelheim, Hexal, Profil Deutschland, IAD, Sanofi, Aventis, Astra Zeneca, Amgen, and Abbvie. All other authors have no competing interests to declare.

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