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Comparison of the Impact of Conventional Hemodialysis and Hemodiafiltration Techniques on the Evolution of Certain Mineral Bone Parameters in Chronic Hemodialysis Patients

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Abstract

AIM: The aim of this study was to compare the impact of conventional hemodialysis (HDC) and hemodiafiltration (HDF) techniques on the evolution of the parameters of phosphocalcic metabolism in chronic hemodialysis patients.

METHODS: This is a retrospective, descriptive, and analytical study carried out in the hemodialysis center of Agadir medico-surgical center during 2015. The total number of patients is 34, 18 were treated by HDC, that is, 52.9% of cases. Furthermore, 16 patients underwent HDF, that is, 47.1% of cases. With each of the two techniques, the following parameters were measured: To assess the PTH level, we performed three measurements. To evaluate calcium, phosphorus, albumine and CRP levels, seven measurements were taken. The data were entered *via* Excel and analyzed through Jamovi 1.6.9 software. We used the Wilcoxon or the Mann–Whitney test for the means. The factors associated with the variation of the studied parameters were analyzed in univariate and multivariate analyzes using the binary logistic regression model.

RESULTS: Our population was made up of 41.2% women and 58.8% men. Their average age was 55 ± 11 years. Furthermore, 82.3% of cases had a normal build, 11.7% were overweight, and 6% were moderately obese. The distribution of patients according to the causal nephropathy of chronic renal insufficiency presented a predominance of diabetic nephropathy (32.3%), followed by vascular pathology in ten patients (29.4%). There was no statistically significant difference in the evolution of the levels of the parameters studied (PTH, calcium, phosphorus, albumin, and CRP levels) over time. Univariate analysis showed that only the initial nephropathy factors: Other nephropathy-vascular nephropathy (p = 0.028; OR = 0.060; IC95% [0.004−0.734]) and diabetic nephropathy-vascular nephropathy (p = 0.011; OR = 0.050; IC95% [0.004−0.508]) were associated with the variation of the studied parameters. The same factors also emerge in the multivariate analysis: Other nephropathy-vascular nephropathy (p = 0.034; OR = 0.044; IC95% [0.002−0.791]) and diabetic nephropathy-vascular nephropathy (p = 0.009; OR = 0.032; IC95% [0.002−0.429]).

CONCLUSION: According to our results, it seems that there are no significant differences in the evolution of some mineral bone parameters studied with the HDC and HDF techniques.

Introduction

The kidneys play the role of a real «sewage treatment plant» in our body. They are essential for maintaining homeostasis in our body [1], [2]. However, under certain conditions kidney function can deteriorate and cause kidney failure, even leading to end stage renal disease when the kidneys are no longer able to perform their function. At this stage, replacement treatments are essential to survive [3], [4], [5], [6]. Extrarenal replacement by dialysis is today a recognized and widely proven therapeutic modality for end-stage chronic renal disease (ESRD). The latter is a serious, disabling pathology, with restrictive and expensive treatment. It is characterized by a set of clinical signs and humoral abnormalities which constitute the uremic syndrome: Arterial hypertension refractory to pharmacological treatment, global hyperhydration with edemas, metabolic acidosis, retention of substances such as urea, creatinine, and potassium [7], [8]. ESRD represents a major public health problem and is a major concern in Morocco because of its medical and socioeconomic consequences [9].

To ensure the survival of the patient, ERST requires the implementation of techniques to support renal function. Apart from few cases where the first replacement therapy is the transplant (preemptive transplant), the first-line treatment is extrarenal purification, which includes: conventional hemodialysis and hemodiafiltration. The objective of extrarenal purification is to overcome the deficit in the excretory function of the kidneys [10].

The survival of nearly 3 million uremic patients worldwide is ensured by extrarenal replacement,

mainly by hemodialysis [11]. In addition, phosphocalcic abnormalities are frequent in chronic renal failure long before the stage of dialysis and play a fundamental role in the development of hyperparathyroidism. These abnormalities constitute an additional cardiovascular risk factor in these patients already presenting many risk factors that are not specific (age, tobacco, diabetes, etc.) or specific to chronic renal failure (lipid disorders, anemia, hyperhomocysteinemia, inflammation, etc.) [12], [13].

Conventional hemodialysis is the most widely used means of renal replacement in Morocco.

However, this conventional hemodialysis technique has its limits. In fact, in the long term, conventional hemodialysis can be accompanied by a morbidity known under the term "pathology of old dialysis patients," significant mortality and also a deterioration in the quality of life of patients [10]. Conventional hemodialysis is present in all hemodialysis centers. On the other hand, hemodiafiltration (HDF) has just been introduced in few centers. It increases the clearance of medium to large molecules by combining diffusive and convective transport [14].

Data from the literature suggest the use of the HDF technique as a hemodialysis treatment for the following reasons: Technological development in water treatment and advances in dialysis machines, as well as the widespread use of synthetic dialyzers. High flux [15]. Furthermore, to our knowledge, virtually no adverse effects of HDF have been published in the literature to date [15]. In addition, patients on HDF would have a better quality of life and fewer symptoms of depression [16], [17]. As well as better hemodynamic stability, especially when using higher convective volumes [18], [19], [20].

The aim of the study is to compare the impact of conventional hemodialysis (HDC) and hemodiafiltration (HDF) techniques on the evolution of the parameters of phosphocalcic metabolism (parathyroid hormone (PTH), calcium, and phosphoremia) in chronic hemodialysis patients.

Methods

This is a retrospective, descriptive, and analytical study carried out in the hemodialysis center of the first Agadir medico-surgical center from June 2015 to December 2015.

We included in our study patients over 18 years old with the following characteristics: (1) Chronic dialysis for more than 6 months, 3 times per week; (2) having an adequate quality of dialysis; and (3) under erythropoiesis stimulating agent. Therefore, we excluded from our study patients who had undergone surgery or had a scheduled transplant as well as patients with bleeding or vascular access dysfunction.

Patients were treated by conventional bicarbonate hemodialysis on AK 200 ultragenerators (Gambro®), with high permeability synthetic membrane and ultrapure dialysate. Or by on-line hemodiafiltration on AK 200 ultragenerators (Gambro®), with high permeability synthetic membrane and ultrapure dialysate, with a replacement liquid prepared on line.

With each of the two techniques, the following parameters were measured: To assess the parathyroid hormone level, we performed three measurements (initial measurement; trimester 1 and trimester 2). To evaluate calcium, phosphorus, albumine and C reactive protein levels, seven measurements were taken (initial, 1st, 2nd, 3rd, 4th, 5th, and 6th months).

Qualitative variables were expressed in number and percentage. Quantitative variables were expressed as mean and standard deviation or median and quartile. For the comparison of the groups, we used the Wilcoxon or the Mann–Whitney test for the means depending on normality test. Furthermore, the factors associated with the variation of some biochemical parameters in dialysis patients were studied in univariate and multivariate analyzes using the binary logistic regression model (enter method). The significance level has been set at $p < 0.05$.

The data were analyzed through Jamovi 1.6.9 software.

Results

Demographic data

Our population consists of 20 women (41.2%) and 14 men (58.8%). The ages of the patients ranged from 18 to 75 years, with a mean age of 55 ± 11 years. The average weight was 70 kg ± 14 kg and the average height is 1.66 m ± 0.08 m (Table 1).

Table 1: Demographics data

Demographic parameter	n (%)	Mean ± standard deviation
Gender		
Male	14 (41.2)	
Female	20 (58.8)	
Age (year):		55.5 ± 11.6
Weight (Kg)		70 ± 14.7
Height (m)		1.66 ± 0.08
Seniority of hemodialysis		7 ± 6

The body mass index (BMI) is a simple measure of weight for height. It is commonly used to express overweight and obesity in adults. It corresponds to the weight divided by the square of the height and expressed in kg/m^2.

The patients in our study were divided according to their BMI (according to the WHO) into:

- 82.3% of cases had a normal build, that is, 28 patients.
- 11.7% of cases were overweight, that is, four patients.
- 6% of cases were moderately obese, that is, two patients.

In our series, the length of hemodialysis ranged from 1 to 20 years with an average of 7 years ± 6 years.

Distribution according to the technique used

In our study population, 18 (52.9%) patients were treated by conventional hemodialysis and 16 (47.1%) patients underwent hemodiafiltration (Table 2).

Table 2: Description of some parameters related to dialysis

Dialysis parameter	n (%)
HDF/HDC	
HDF	16 (47.1)
HDC	18 (52.9)
Blood group	
A	9 (26.5)
B	10 (29.4)
AB	10 (29.4)
O	5 (14.7)
Initial nephropathy	
Diabetic nephropathy	11 (32.4)
Vascular nephropathy	10 (29.4)
Others (lupus, polycystosis, indeterminate)	13 (38.24)
Surface area of the membrane	
2.1	3 (8.8)
1.7	3 (8.8)
1.4	28 (82.4)

HDC: Hemodialysis, HDF: Hemodiafiltration.

Type of hemodialysis membrane

Among the 34 patients, a high permeability membrane with an area of 2.1 m^2 was used in 28 (88.2%) patients, an area of 1.7 m^2 was used in 3 (8.8%) patients, and area of 1.4 m^2 was used in 3 (8.8%) patients (Table 2).

Initial nephropathy

In the population studied, the distribution of patients according to the nephropathy causing chronic renal failure showed a predominance of diabetic nephropathy in 11 (32.2%) patients, followed by vascular pathology in 10 (29.4%) patients. Then, lupus nephropathy concerns 4 (11.7%) of our patients, followed by polycystic kidney disease which was present in 2 (5.8%) patients. Nevertheless, the etiology was undetermined in 7 (20.8%) patients (Table 2).

Evolution of mineral bone parameters

We evaluated the evolution of various parameters (parathyroid hormone, calcium, phosphorus, albumin, and C reactive protein levels) over time depending on the dialysis technique used. Our results show no statistically significant difference in the evolution of the levels of the various parameters, with the exception of the level of phosphorus between the 6th and 7th measurement with the HDC dialysis technique (p = 0.03) and the calcium level between the 3rd and 4th measurement with the HDF dialysis technique (p = 0.023) (Tables 3 and 4).

Table 3: Comparison of the means of some biological parameters studied in patients on hemodiafiltration dialysis, comparison of the groups was led by Wilcoxon or Mann–Whitney test for the means

Biological parameter	Mean	p
PTHi		
PTHi1-PTHi2	247.36–402.59	0.091
PTHi2-PTHi3	402.59–437.80	0.625
PTHi1-PTHi3	247.36–437.80	0.193
CRP		
CRP1-CRP2	12.53–11.62	0.530
CRP2-CRP3	11.62–12.85	0.755
CRP3-CRP4	12.85–11.27	0.469
CRP4-CRP5	11.27–8.65	1.000
CRP5-CRP6	8.65–12.43	0.505
CRP6-CRP7	12.43–10.50	0.498
CRP1-CRP7	12.53–10.50	1.000
Phos		
Phos1-Phos2	31.53–35.56	0.125
Phos2-Phos3	35.56–30.95	0.530
Phos3-Phos4	30.95–38.33	0.410
Phos4-Phos5	38.33–58.93	0.451
Phos5-Phos6	58.93–37.75	0.076
Phos6-Phos7	37.75–32.33	0.438
Phos1-Phos7	31.53–32.33	0.590
Albu		
Albu1-Albu2	37.19–37.51	0.191
Albu2-Albu3	37.51–36.50	0.371
Albu1-Albu3	37.19–36.50	0.850
CA		
CA1-CA2	88.36–88.74	0.147
CA2-CA3	88.74–88.38	0.551
CA3-CA4	88.38–91.56	0.023
CA4-CA5	91.56–89.19	0.977
CA5-CA6	89.19–87.56	0.162
CA6-CA7	87.56–86.86	0.150
CA1-CA7	88.36–86.86	0.752

PTHi: Parathormone, CRP: C-reactive protein, Phos: Phosphorus, Albu: Albumin, CA: Calcium.

We thus carried out univariate and multivariate analyzes to determine the factors which may be associated with a variation in the parameters of

Table 4: Comparison of the means of some biological parameters studied in patients on hemodialysis dialysis, comparison of the groups was led by Wilcoxon or Mann–Whitney test for the means

Biological parameter	Mean	p
PTHi		
PTHi1-PTHi2	296.01–338.18	0.765
PTHi2-PTHi3	338.18–495.97	0.469
PTHi1-PTHi3	296.01–495.97	0.297
CRP		
CRP1-CRP2	17.07–7.61	0.052
CRP2-CRP3	7.61–4.82	0.438
CRP3-CRP4	4.82–18.28	0.886
CRP4-CRP5	18.28–4.43	0.529
CRP5-CRP6	4.43–7.72	0.059
CRP6-CRP7	7.72–22.58	0.833
CRP1-CRP7	17.07–22.58	0.673
Phos		
Phos1-Phos2	37.56–33.06	0.615
Phos2-Phos3	33.06–40.41	0.068
Phos3-Phos4	40.41–37.44	0.678
Phos4-Phos5	37.44–41.36	0.235
Phos5-Phos6	41.36–32.60	0.446
Phos6-Phos7	32.60–45.29	0.031
Phos1-Phos7	37.56–45.29	0.219
Albu		
Albu1-Albu2	36.38–42.20	0.206
Albu2-Albu3	42.20–36	0.500
Albu1-Albu3	36.38–36	0.500
CA		
CA1-CA2	85.11–87.06	0.868
CA2-CA3	87.06–85.76	0.889
CA3-CA4	85.76–88.29	0.170
CA4-CA5	88.29–87.69	0.977
CA5-CA6	87.69–88.08	0.343
CA6-CA7	88.08–86.11	0.439
CA1-CA7	85.11–86.11	0.447

PTHi: Parathormone, CRP: C-reactive protein, Phos: Phosphorus, Albu: Albumin, CA: Calcium.

phosphocalcic metabolism depending on the technique used. The results of the univariate analysis showed that only the initial nephropathy factor other nephropathy-vascular nephropathy (p = 0.028; OR = 0.060; IC95% [0.004−0.734]) and nephropathy factor diabetic nephropathy-vascular nephropathy (p = 0.011; OR = 0.050; IC95% [0.004−0.508]) were associated with the aforementioned variation.

The same factors also emerge in the multivariate analysis: other nephropathy-vascular nephropathy (p = 0.034; OR = 0.044; IC95% [0.002−0.791]) and diabetic nephropathy-vascular nephropathy (p = 0.009; OR = 0.032; IC95% [0.002−0.429]) (Table 5).

Discussion

In this study, we were interested in comparing the impact of conventional hemodialysis and hemodiafiltration techniques on the evolution of certain parameters of phosphocalcic metabolism in chronic hemodialysis patients from the first Agadir medico-surgical center. Several parameters were thus evaluated. Our population was made up of 41.2% women and 58.8% men. Their average age was 55 ± 11 years. In addition, 82.3% of cases were normal build, 11.7% of cases were overweight, and 6% of cases were moderately obese. Our data showed that 52.91% of our patients were treated by conventional hemodialysis, the others (47.1%) by hemodiafiltration. In addition, 29.4% of cases were Group B, the same percentage is found for patients with blood Group AB, 26.5% were blood Group A, and finally 14.7% of cases were blood Group O. The distribution of patients according to nephropathy causing chronic renal failure showed a predominance of diabetic nephropathy (32.3%) followed by vascular pathology in ten patients or 29.4% of cases.

We evaluated the change in the means of parathyroid hormone, calcium, phosphorus, albumin, and C reactive protein levels, over time depending

Table 5: Univariate and multivariate analyzes of the factors associated with the variation of some biochemical parameters in dialysis patients. Binary logistic regression model

	n(%)	Univariate analysis				Multivariate analysis			
		p	OR	CI 95%		p	Adjusted OR	IC 95%	
				Inf	Sup			Inf	Sup
Gender									
Male		1							
Female	20 (58.8)	0.327	2.000	0,500	8.00	-	-	-	-
Age		0.523	1.020	0.9603	1.08	-	-	-	-
Weight		0,265	0.972	0,925	1,02	-	-	-	-
height		0,051	$6,65.10^{-5}$	$4,19.10^{-5}$	1,05	-	-	-	-
Blood group						-	-	-	-
B-A		0.500	1.875	0.302	11.63				
AB-A		0.809	1.250	0.205	7.62	-	-	-	-
O-A		0.579	1.875	0.204	17.27	-	-	-	-
Right-handed/left-handed		0.995	$1.47.10^{7}$	0.000	Inf	-	-	-	-
Initial nephropathy		1							
Other nephropathy-Vascular nephropathy		0.028	0.060	0.004	0.734	0.034	0.044	0.002	0.791
Diabetic Nephropathy-Vascular Nephropathy		0.011	0.050	0.004	0.508	0.009	0.032	0.002	0.429
Diaphragm type		1				-	-	-	-
$1,7m^2$-$2,1m^2$		1.000	1.000	0.0335	29.81				
$1,4m^2$-$2,1m^2$		0.589	0.500	0.040	6.17				
Dialysis seniority		0.584	0.969	0.866	1.08	-	-	-	-
Calcemia									
CA1		0.422	0.975	0.916	1.04	-	-	-	-
CA2		0.511	0.969	0.883	1.06	-	-	-	-
CA3		0.395	0.965	0.8904	1.05	-	-	-	-
CA4		0.257	0.949	0.868	1.04	-	-	-	-
CA5		0.711	0.988	0.929	1.05	-	-	-	-
CA6		0.871	1.007	0.924	1.10	-	-	-	-
CA7		0.867	0.990	0.885	1.11	-	-	-	-
Phosphoraemia									
Phospho 1		0.162	1.045	0.982	1.11	-	-	-	-
Phospho 2		0.555	0.928	0.928	1.04	-	-	-	-
Phospho 3		0.141	1.037	0.9882	1.09	-	-	-	-
Phospho 4		0.881	0.997	0.955	1.04	-	-	-	-
Phsopho 5		0.478	0.994	0.976	1.01	-	-	-	-
Phospho 6		0.234	0.945	0.861	1.04	-	-	-	-
Phospho 7		0.161	1.068	0.973	1.17	-	-	-	-
Albuminemia									
Albu 1		0.483	0.923	0.737	1.15	-	-	-	-
Albu 2		0.395	1.096	0.887	1.36	-	-	-	-
Albu 3		0.795	0.902	0.416	1.96	-	-	-	-
Parathormone									
PTHi1		0.528	1.001	0.998	1.00	-	-	-	-
PTHi 2		0.612	0.999	0.997	1.00	-	-	-	-
PTHi 3		0.704	1.001	0.997	1.00	-	-	-	-
CRP									
CRP1		0.582	1.009	0.977	1.04	-	-	-	-
CRP2		0.259	0.957	0.886	1.03	-	-	-	-
CRP3		0.103	0.914	0.821	1.02	-	-	-	-
CRP4		0.617	1.005	0.985	1.03	-	-	-	-
CRP5		0.097	0.893	0.781	1.02	-	-	-	-
CRP6		0.362	0.963	0.889	1.04	-	-	-	-
CRP7		0.492	1.013	0.997	1.05	-	-	-	-

n: number ; %: percentage; p: *P* value; OR: Odds Ratio; Inf: Inferior; Sup: Superior; CI 95%: 95% Confidence Interval, 1 represents the reference group CI.

on the dialysis technique used. Our results show no statistically significant difference in the evolution of the levels of the various parameters studied as a function of time, with the exception of the level of phosphorus in the blood between the 6th and 7th measurement with the HDC dialysis technique (p = 0.03) and the calcium level between the 3rd and 4th measurement with the HDF dialysis technique (p = 0.023) (Table 4).

We thus carried out univariate and multivariate analyzes to determine the factors associated with a variation in the parameters of phosphocalcic metabolism depending on the technique used. The results of the univariate analysis showed that only the initial nephropathy factor other nephropathy-vascular nephropathy (p = 0.028; OR = 0.060; IC95% [0.004−0.734]) and nephropathy factor diabetic nephropathy-vascular nephropathy (p = 0.011; OR=0.050; IC95% [0.004−0.508]) were associated with this variation.

The same factors also emerge in the multivariate analysis: other nephropathy-vascular nephropathy (p = 0.034; OR = 0.044; IC95% [0.002−0.791]) and diabetic nephropathy-vascular nephropathy (p = 0.009; OR = 0.032; IC95% [0.002−0.429]) (Table 5).

By comparing the age of our patients, which varied between 18 and 75 years, with an average age of 55 ± 11 years, with the data of the literature, we found that our population has a younger age than that described in the study by Oates *et al*. who reported an average age of 68, and in the series by Van der Weed *et al*. who described an average age of 64 [21], [22]. Furthermore, in our series, we found a female predominance with 20 women for 14 men, i.e. a sex ratio of 0.7. The opposite was found in the study by Oates and that of Van der Weed *et al*. where a male predominance was noted in 54% of cases with a sex ratio of 1.3. The same was true in the Van der Weed *et al*. study, with a sex ratio of 1.5 [21], [22].

We were also interested in comparing the evolution of the averages of the parameters involved in calcium phosphate metabolism with the literature. We started by comparing the mean parathormone (PTH) which was 440 ng/l ± 266 for HDF and 364 ng/l ± 266 for HDC, with a statistically non-significant difference (p = 0.3). This is found in the series by Oates *et al*. with PTH means of 269 ng/l ± 45 in HDF and 256 ng/l ± 44 in HDC, and in the series by Van der WEED *et al*. with PTH means 193 g/l in HDF and 194 ng/l in HDC [21].

Regarding serum calcium, in our series, the average HDF serum calcium was 87.4 mg/dl ± 6.9 and 86.4 mg/dl ± 6.9 in HDC with p = 0.6. This average is close to those of the studies by Richard *et al*., and Oates *et al*., 2010 [21]. Indeed in the study by Richard *et al*., the average serum calcium in HDF was 94 mg/l, and that in HDC was 93 mg/l with a non-significant difference (p = 0.6) [23]. In the study by Oates *et al*., the average serum calcium in HDF was 92 mg/l and that in HDC was 97 mg/l with a non-significant difference.

Concerning phosphoremia, in our series, the mean HDF phosphoremia was 38.23 mg/l ± 10 and the mean HDC was 41.36 mg/l ± 9, with a non-significant p. In the study by Richard *et al*., the mean HDF phosphoremia was 48 mg/l ± 2, and the mean HDC was 49 mg/l ± 3 with also a non-significant difference (p = 0.7) [23].

As for C-reactive protein (CRP), which is protein that reflects inflammation and rises very quickly during inflammatory processes. The normal value is between 0 and 10 mg/dl. In our series, the average CRP in HDF was 5.9 mg/dl ± 4 and the average in HDC was 4.96 mg/dl ± 2 with a non-significant p (p = 0.4). The study by Oates *et al*., for example, described an average CRP in HDF equal to 9 mg/dl and that in HDC equal to 7 mg/dl with a non-significant difference as well [21].

Finally, concerning the initial nephropathy, in our series, diabetic nephropathy was the leading cause of chronic hemodialysis with 32.3%, followed by vascular pathology with 29.4% of cases. This result is comparable to that found in the study by Oates *et al*., with initial diabetic nephropathy present in 35.3% of cases, whereas in the study by Van der Weed *et al*., it was only present in 21% of cases [21], [22]. Vascular pathology was responsible for 29% of cases.

References

1. Su W, Cao R, Zhang XY, Guan Y. Aquaporins in the kidney: Physiology and pathophysiology. Am J Physiol Renal Physiol. 2020;318(1):F193-203. https://doi.org/10.1152/ajprenal.00304.2019
   PMid:31682170
2. Palmer BF, Clegg DJ. Physiology and pathophysiology of potassium homeostasis. Adv Physiol Educ. 2016;40(4):480-90. https://doi.org/10.1152/advan.00121.2016
   PMid:27756725
3. Dhondup T, Qian Q. Electrolyte and acid-base disorders in chronic kidney disease and end-stage kidney failure. Blood Purif. 2017;43(1-3):179-88. https://doi.org/10.1159/000452725
   PMid:28114143
4. Trajceska L, Mladenovska D, Dzekova-Vidimliski P, Sikole A. Quality of life-repeated measurements are needed in dialysis patients. Open Access Maced J Med Sci. 2018;6(8):1410-2. https://doi.org/10.3889/oamjms.2018.305
   PMid:30159066
5. Jabbar A, Qureshi R, Dhrolia M, Nasir K, Ahmad A. Variety of cardiac events in hospitalized chronic kidney disease patients. Cureus. 2021;13(10):e18801. https://doi.org/10.7759/cureus.18801
   PMid:34804663
6. Jha CM. Cost-effectiveness of home hemodialysis with bedside portable dialysis machine “DIMI” in the United Arab Emirates. Cureus. 2021;13(10):e18549. https://doi.org/10.7759/cureus.18549
   PMid:34754693
7. Chen TK, Knicely DH, Grams ME. Chronic kidney disease diagnosis

and management: A review. JAMA. 2019;322(13):1294-304. https://doi.org/10.1001/jama.2019.14745

PMid:31573641

8. Reynolds BS, Lefebvre HP. Feline CKD: Pathophysiology and risk factors--what do we know? J Feline Med Surg. 2013;15(Suppl1):3-14. https://doi.org/10.1177/1098612X13495234

PMid:23999182

9. Asserraji M, Maoujoud O, Belarbi M, Oualim Z. Epidemiological profile of end stage renal disease at the Military Hospital in Rabat, Morocco. Pan Afr Med J. 2015;20:439. https://doi.org/10.11604/pamj.2015.20.439.3352

PMid:26309471

10. Goodkin DA, Bragg-Gresham JL, Koenig KG, Wolfe RA, Akiba T, Andreucci VE, *et al*. Association of comorbid conditions and mortality in hemodialysis patients in Europe, Japan, and the United States: The dialysis outcomes and practice patterns study (DOPPS). J Am Soc Nephrol. 2003;14(12):3270-7. https://doi.org/10.1097/01.asn.0000100127.54107.57

PMid:14638926

11. Canaud B, Leray-Moragués H. Conduite de l'hémodialyse et prévention de ses complications. EMC-Néphrologie. 2006;1(1):1-21. https://doi.org/10.1016/s1762-0945(06)43988-7

12. Locatelli F, Canaud B, Eckardt KU, Stenvinkel P, Wanner C, Zoccali C. Oxidative stress in end-stage renal disease: An emerging threat to patient outcome. Nephrol Dial Transplant. 2003;18(7):1272-80. https://doi.org/10.1093/ndt/gfg074

PMid:12808161

13. Roumeliotis S, Mallamaci F, Zoccali C. Endothelial dysfunction in chronic kidney disease, from biology to clinical outcomes: A 2020 update. J Clin Med. 2020;9(8):2359. https://doi.org/10.3390/jcm9082359

PMid:32718053

14. Canaud B, Vienken J, Ash S, Ward RA, Kidney Health Initiative HDF Workgroup. Hemodiafiltration to address unmet medical needs ESKD patients. Clin J Am Soc Nephrol. 2018;13(9):1435-43. https://doi.org/10.2215/CJN.12631117

PMid:29511057

15. Maduell F. Hemodiafiltration versus conventional hemodialysis: Should "conventional" be redefined? Semin Dial. 2018;31(6):625-32. https://doi.org/10.1111/sdi.12715

PMid:29813181

16. Almueilo SH. In: Karkar A, editor. Quality of Life on Online Hemodiafiltration (HDF). Ch. 08. Rijeka: IntechOpen; 2016. https://doi.org/10.5772/64591

17. Su SF, Ng HY, Huang TL, Chi PJ, Lee YT, Lai CR, *et al*. Survey of depression by Beck Depression Inventory in uremic patients undergoing hemodialysis and hemodiafiltration. Ther Apher Dial. 2012;16(6):573-9. https://doi.org/10.1111/j.1744-9987.2012.01094.x

PMid:23190518

18. Maduell F, Moreso F, Pons M, Ramos R, Mora-Macià J, Carreras J, *et al*. High-efficiency postdilution online hemodiafiltration reduces all-cause mortality in hemodialysis patients. J Am Soc Nephrol. 2013;24(3):487-97. https://doi.org/10.1681/ASN.2012080875

PMid:23411788

19. Schiffl H, Lang SM, Fischer R. Effects of high efficiency post-dilution on-line hemodiafiltration or conventional hemodialysis on residual renal function and left ventricular hypertrophy. Int Urol Nephrol. 2013;45(5):1389-96. https://doi.org/10.1007/s11255-012-0336-4

PMid:23225079

20. Mora-Bravo FG, De-La-Cruz G, Rivera S, Ramírez AM, Raimann JG, Pérez-Grovas H. Association of intradialytic hypotension and convective volume in hemodiafiltration: Results from a retrospective cohort study. BMC Nephrol. 2012;13:106. https://doi.org/10.1186/1471-2369-13-106

PMid:22963170

21. Oates T, Pinney JH, Davenport A. Haemodiafiltration versus high-flux haemodialysis: Effects on phosphate control and erythropoietin response. Am J Nephrol. 2011;33(1):70-5. https://doi.org/10.1159/000322834

PMid:21178336

22. van der Weerd NC, Den Hoedt CH, Blankestijn PJ, Bots ML, van den Dorpel MA, Lévesque R, *et al*. Resistance to erythropoiesis stimulating agents in patients treated with online hemodiafiltration and ultrapure low-flux hemodialysis: Results from a randomized controlled trial (CONTRAST). PLoS One. 2014;9(4):e94434. https://doi.org/10.1371/journal.pone.0094434

PMid:24743493

23. Ward RA, Schmidt B, Hullin J, Hillebrand GF, Samtleben W. A comparison of on-line hemodiafiltration and high-flux hemodialysis: A prospective clinical study. J Am Soc Nephrol. 2000;11(12):2344-50. https://doi.org/10.1681/ASN.V11122344

PMid:11095657