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ORIGINAL ARTICLE

Regulation of Venous and Arterial Pressures is Crucial in Preventing Vascular Dysfunction During Dialysis and its Impact on the Effectiveness of the Dialysis Dose

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ABSTRACT

Background: Vascular access is one of the essential elements to be able to carry out hemodialysis treatment. The ideal vascular access it must have at least three characteristics: Allow the safe and continuous approach to the vascular system, provide sufficient flows that allow to supply the scheduled dialysis dose and be free of complications.

Objective: To assess the pressures dynamics of our patients, adapt them to the latest recommendations on the limit of the same and analyze how did the pressure control affect the Qb and in turn about the dialysis dose.

Patients and methods: A prospective study was conducted on all patients with chronic kidney disease in conventional hemodialysis program and carriers of native or prosthetic arteriovenous fistula after the period of maturation.

Results: In period 0, 83% of the patients presented a venous pressure >160 mm Hg and 21% arterial pressure < -200 mm Hg. In period 1, after the flow intervention, 20% of patients had venous pressure > 160 mm Hg and 3.4% arterial pressure < -200 mm Hg. In period 3, 100% of patients are with safe pressures. In relation to Kt: period 0 average of 49 l, period 1 average 46.8l and period 2 is recovered to 50.65l (p<0.001). For this purpose, 21 interventions were performed on 18 patients individually in period 2.

Conclusion: A decrease in the pump flow that negatively affects the dialysis dose, therefore, it would be necessary to make changes of patterns in an individualized way to recover the lost dialytical effectiveness

Keywords: **Vascular access, vascular dysfunction, Hemodialysis, Venous pressure, Arterial pressure**

1. INTRODUCTION

Despite advances in the treatment of patients with chronic kidney disease on hemodialysis, vascular access remains one of the most important challenges in all dialysis units. Although it is generally accepted that the vascular access of choice is the native arterio venous fistula, as it has a lower rate of infection, complications and greater long-term patency, the reality is that the use of the central venous catheter has been progressively increasing, especially in older patients with associated comorbidities. This superiority of fistula over catheter is based on observational studies showing worse clinical outcomes and higher mortality in hemodialysis patients with catheter as vascular access, although they may contain confounding factors (1,2). HD is an extracorporeal blood purification technique that supplies partially the renal functions of excreting water and solutes, and of regulating the acid-base and electrolyte balance. It does not support endocrine functions or renal metabolic (3). This technique basically consists of interposing between 2 compartments liquids (blood and dialysis liquid), a semi-permeable membrane. The membrane allows the passage of substances depending on their molecular weight. The semi-permeable membrane allows water and solutes of small and medium molecular weight, but not proteins or blood cells, very large as to pass through the pores of the membrane. Therefore, the various substances tend to cross the dialysis membrane to balance the concentrations. The physical mechanisms that regulate these functions are two: the diffusion or transport by conduction and ultrafiltration or transport by convection (4,5). Diffusion consists of the passive transport of solutes across the membrane of the dialyzer and is produced by the difference in concentration between the two compartments. The amount of a solute that diffuses through the membrane depends on two factors. Convective transport consists of the passage simultaneous through the solvent dialysis membrane (plasma water) accompanied by the solutes that can pass through the pores of the membrane, under the effect of a hydrostatic pressure gradient. Ultrafiltration is the fluid removed from the blood through the dialysis membrane by this mechanism. Its function is to eliminate during the dialysis session the liquid retained during the period between dialysis (6). Vascular access (VA) is one of the essential elements to be able to carry out hemodialysis treatment. The ideal vascular access it must have at least three characteristics: Allow the safe and continuous approach to the vascular system, provide sufficient flows that allow to supply the scheduled dialysis dose and be free of complications (7). Currently, the arterio-venous fistula (AVF), is the vascular access that comes closest to these requirements and this is the first way of choosing for the initiation of hemodialysis treatment, given their high survivor (7,8). In this sense, the different clinical guidelines of the VA recommend the periodic application of active follow-up and monitoring programs of the same. Along with the physical examination, the control of dynamic pressures, pre-pump blood pressure (BP) and venous pressure of the circuit (PV), during the session is the first link in the follow-up of the VA, the nurse being the responsible for this procedures (9-11). There are several studies that claim that the higher the PV and the lower the PA, decreases the survivor access (12,13); however, there is no limit number of pressures that is set as safe, although it seems that it is recommended not to exceed the -190mmHg for the PA 11 and as for the PV, according to recent studies, it is recommended to lower the limits accepted as normal from 200mmHg to 150mmHg to increase the long-term survival of VA. Thus the maintenance of the control of dynamic pressures as a factor of irrigation of the VA, it forces us to control the pump flow (Qb). This, together with the time of the session, the urea clearance from the dialyzer and the flow of the dialyzing liquid, are some of the factors involved in the dialysis dose,13 so that by modifying our flows, the dialytical efficiency could be affected and require further adjustments to the dialysis schedule (14,15). Aim of the study was to assess the pressures dynamics of our patients, adapt them to the latest recommendations on the limit of the same and analyze how did the pressure control affect the Qb and in turn about the dialysis dose.

2. METHODOLOGY

A prospective study was conducted on all patients with chronic kidney disease in conventional hemodialysis program and carriers of native or prosthetic arteriovenous fistula after the period of maturation.

Study variables: Primary variables: Hemodialysis (HD), Pump flow (Qb), Venous pressure (PV) and arterial pressure (PA) and KT measured by ionic dialysance.

Secondary variables: Demographic variables (age, sex and etiology of CKD). Variables related to dialysis (Time on dialysis, type of vascular access and time of the same, dialyzer, bath flow (Qd) and caliber of needles). It was considered as safe limits for VA, to dialyze with PV maximum of 160mm Hg and minimum PA of -200mm Hg, rounding the figure of 150mm Hg and 190mm Hg, monitors were used and the reading display will mark values 140 or 160 mm Hg in case of PV and -180 or - 200mm Hg in case of PA.

To assess the dialysis dose, the measurement of the Kt. Lowrie EG et al, recommend a minimum Kt of 40-45 liters in women and 45-50 liters in men (16), later this will be validated, considering Kt is a good marker of the dialysis dose,(17) even some authors point to it as the best indicator in situation of under dialysis. (18)

Moreover, from a point of view of the nurse performance, continuous measurement of the dose by means of the Kt allows to know the efficacy in each session without the need to perform extractions blood series. For the analysis of the KT results was divided by both the sample based on sex, and 4 were established groups of values:

Group 1 patients with kt less than 40l.

Group 2 patients with kt between 40-45l.

Group 3 patients with kt between 45-50l.

Group 4 patients with kt greater than 50l.

Three time periods were determined to be analyzed:

Period 0: 15 sessions per patient without modifying VA flow parameters, in which the QB was at nursing criteria, measuring QB, PV and PA and kt obtained.

Period 1: 15 sessions per patient, in which it was scheduled a non-modifiable pump flow, which was established by assessing during three sessions that the venous pressures and arterial lines were within the defined limits previously as insurance. In this period the rest of the HD pattern of period 0 was maintained: Membrane, HD time, bath flow, gauge of the needles.

Period 2: 15 sessions in which the QB was adjusted in the different sessions so as not to exceed in any case PV 160mm Hg or PA -200mm Hg and also the dialysis schedule was modified (dialysis time, the needles, membrane size, bath flow), in function to the changes in the dialysis dose (measured by Kt) produced between period 0 and 1, individually and according to the personal characteristics of every patient. The statistical analysis was carried out with the program SPSS 15.0 for Window 10. A descriptive study of the main demographic data was carried out, it was used as measures of central dispersion in some cases the mean and standard deviation or the median and the range according to the normal behavior of the variables. It he compared the different variables of the study as data pairs of each patient in the different periods of the I study. The statistical significance analysis for $p \leq 0.05$ was specified using non-parametric tests with Friedman test for intra period differences and Wilcoxon sign ranges test for differences inter periods since many of the variables did not follow a normal distribution.

3. RESULTS

There were 29 patients included, the main demographic data are described in (**Table 1**). The descriptive analysis of the variables under study in the different periods were detailed in (**Table 2**). In this same table was analyzed the variation of the Kt in the different periods. In period 0, 82.7% of patients were dialyzed with PV figures above 160 mm Hg and the 20.7% with BP figures higher than -200mm Hg. By lowering the flows to control the dynamic pressures, the dialytic efficiency decreased from 49.3 L to 46.8 L in period 1 and recovered to 49.6 L in period 2 and these differences were statistically significant ($p<0.001$), between the 3 periods. The differences were especially important between period 0 and period 1 and between period 1 and 2 ($p< 0.001$), bordering on the significance between period 0 and 2 $p=0.05$. In period 2, after intervention on other factors of the dialysis regimen, 100% of men have been dialyzed above 45 L, 80% of the women above 45 L and 100% of women above 40 L. Were studied, the significant differences in the changes of PV and PA made after the adjustment of flows and as these have been maintained in period 2 after the intervention (**Table 3**). There were also differences in the Qb between period 0 and period 1 in which the flows go down and as these were recovered with the intervention performed, being the differences between the basal period and the final not significant. As soon as the interventions on the usual pattern performed between period 1 and 2, 21 interventions were performed on the 29 patients whose distribution it is reflected in (**Figure 1**). The patients' patterns in the three periods were described in (**Table 4**).

Table 1. Characteristics patients on dialysis and vascular access.

Variables		No.	%
Age	Mean	62.3	
	SD	11.5	
	Range	24-81	
Sex	Male	19	65.5
	Female	10	34.5
Causes of renal insufficiency	DM	9	31
	Glomerular	5	17
	Vascular	3	10
	Interstitial	4	14
	Unknown	8	27
Type of vascular access	Native Arterio-Venous Fistula	26	89.7
	Prosthetic Arterio-Venous fistula	3	10.3
Duration of the VA (months)	Mean	38.1	
	SD	30.7	
	Range	7-123	

Table 2. Descriptive analysis of the variables under study.

Variable				Period 0	Period 1	Period 2
flow	Medium			391.3	347.9	377.9
	Range			318.56 – 419.4	274 - 396	286.2 - 475
PV > 160 (mmHg)	Medium			178	163	162.9
	Range			137.4 – 195.2	125.6 – 174.1	123.7 – 163.8
	No.			24	6	1
	%			82.7	20.4	3.4
PA > 160 (mmHg)	Medium			-184.8	-171.6	-176.4
	Range value is negative			146.7 – 209.6	106.1 – 208	112.1 –193.6
	No.			6	1	0
	%			20.7	3.4	0.0
Kt	Medium			48.4	45.1	48.8
	Range			35– 64.2	38.3 – 56.5	41.4– 63.7
	Male	< 40	No.	0	0	0
			%	0.0	0.0	0.0
		40-44.9	No.	2	4	0
			%	10.5	21.1	0.0
		45-49.9	No.	8	8	9
			%	42.1	42.1	47.4
		≥50	No.	9	7	10
			%	47.4	36.8	52.6
	Female	< 40	No.	1	2	0
			%	10.0	20.0	0.0
		40-44.9	No.	5	4	2
			%	50.0	40.0	20.0
		45-49.9	No.	0	2	4
			%	0.0	20.0	40.0
		≥50	No.	4	2	4
			%	40.0	20.0	40.0

Table 3. Statistical significance test of the ranges with signs of Wilkinson for paired data of the variables in the study period

Variable	Period 0	Period 1	Period 2
Qb	<0.001	0.004	0.2
PV	<0.001	0.6	<0.001
PA	<0.001	0.5	<0.001
Kt	<0.001	<0.001	0.05

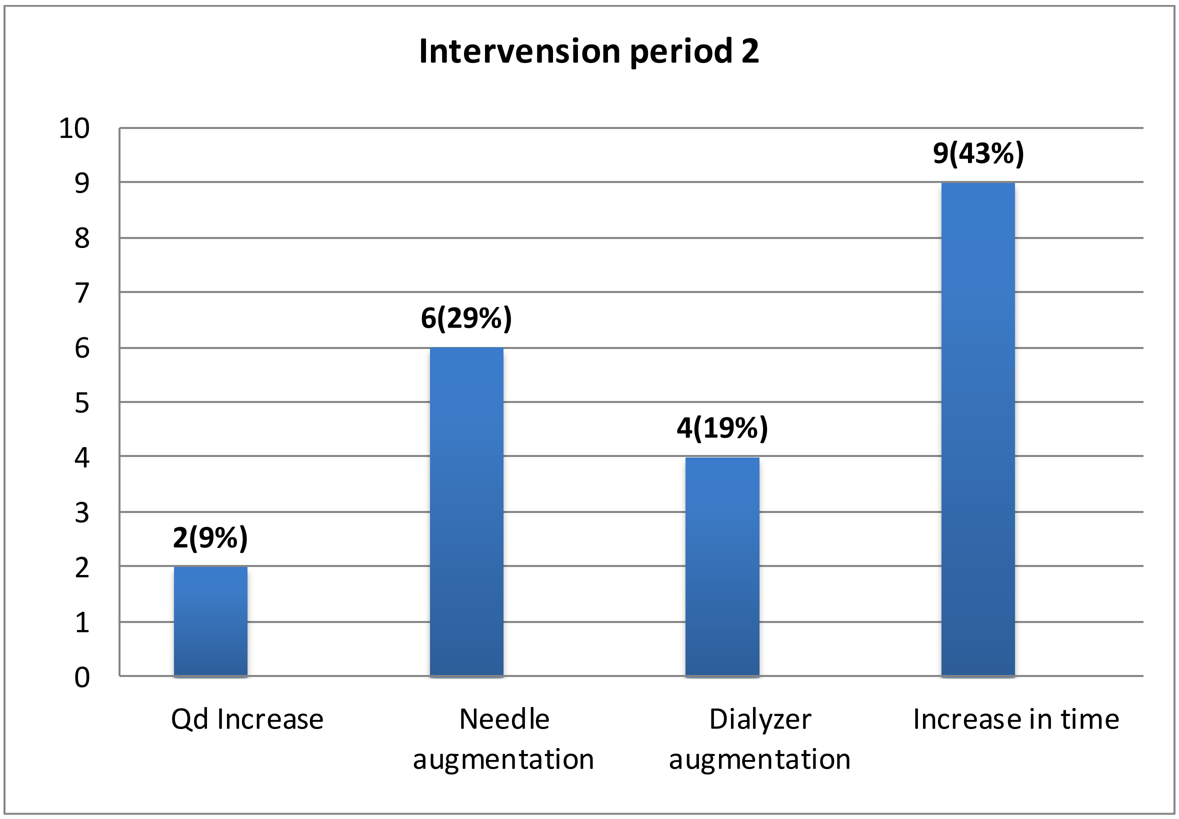

Figure 1. Type of interventions carried out on the usual pattern between period 1 and period 2.

Table 4. The patients' patterns in the 3 periods

Variable		Period 0 and Period 1		Period 2	
		No.	%	No.	%
HD session time /m.		638.52		685.86	
Dialyzer	Helixone 1.8m^2	12	41.4	12	41.4
	Polinephrone 1.9m^2	14	48.3	10	35.5
	Polinephrone 2.1m^2	2	6.9	6	20.7
	Polinephrone 2.5m^2	1	3.5	1	3.5
Bath flow	500 ml/m	29	100.0	27	93.1
	800 ml/m	0	0.0	2	6.9
Type of needle	16G	5	17.3	3	10.4
	15G	24	82.7	22	75.9
	14G	0	0.0	4	13.8

4. DISCUSSION

The control of arteriovenous fistula (AVF) is essential for patients in HD. Within the monitoring of the VA, nursing must control the dynamic pressures (PV and PA) during treatment in order to protect the survival of the VA. An important part of the evaluation of these parameters lies in the evolution of them over of time, since they vary according to the characteristics of the patient and the VA. In this sense, some authors relate a PA negative less than -190 mm Hg with a decrease of the survival of vascular access. This is explained because intimal hyperplasia, a precursor lesion of the stenosis and thrombosis of the vascular access, it originates due to the vibrations and turbulence related to the Qb, and the abnormally high pre-pump PA may contribute to endothelial injury by excessive suction and hemolysis (18,19). As for PV, there are no clear limits in the literature either, although according to a recent study,(15) it is recommended to lower the limits accepted as normal from 200mm Hg to 150mm Hg. This study analyzed the percentage of patients that were being dialyzed with PV and PA values out of the limits currently accepted in the literature. After the analysis, it was found that many of the patients accepted figures, especially of PV higher than the recommended ones. Although the flows of pump, during period 1 not in all patients the pressures dropped to safe limits, 6 patients maintained PV figures higher than 160 mm Hg and in one case the PA was kept below -200mm Hg. It should be borne in mind that hemodynamic parameters may be affected among other things due to changes in the puncture site, poor positioning of the needles, clamping of the systems, viscosity of the blood and arterial hypotension, our medians are were affected by variations in specific sessions, this was corrected in the third period in which a fixed flow pattern is not established, but will depend on the circumstances of the session, so that in the same, all the patients are dialyzed in accepted limits. The administered dialysis dose influences the hemodialysis patient survivor. Among the factors involved in reaching this dose are the time of the session, the effective blood flow, the urea clearance from the dialyzer and the flow of the dialyzing liquid (20,21). In this study, the pump flows mostly decreased and this has affected the dialysis dose of our patients, measured by Kt, in a statistically significant way. Although we want to keep our vascular accesses in good condition, we know the importance of getting proper dialysis. In our study after the loss of dialytical efficiency by lowering the flows the change of pattern was assessed individually more appropriated according to the circumstances of each patient. It performed 21 interventions on the 29 patients, the majority of dialysis time increases by 9 patients, as we know, the treatment time, it is the most important and always effective element on the one we can influence to improve the dosage. The recommendations of the European and Spanish guides are of a time around 12 hours weekly (22,23). In our case of passage from 11.1h to 11.43h weekly obtaining a significant increase in Kt in all cases. As for the size of the needle was made in 6 patients, despite the controversy in the bibliography the use of 14G needles regarding the increase in pain and bleeding with respect to the increase in efficacy, we increased the size, which allowed us to increase the flows again even to values higher than period 0, maintaining figures of pressures for sure (24). Likewise, despite the fact that recent publications question the increase in bathroom flow in front of the increase in time in relation to cost saver, (25) there are several authors who report an increase in the dialysis efficiency of 5-10%28, 29, in two of our patients the Qb was increased from 500 to 800, as this was rated as the best option for increasing effectiveness in these two cases (26,27). Finally, it is known that the surface and permeability of each dialyzer is expressed by its mass transfer area coefficient (KoA), the higher surface area, greater mass transfer. Currently surfaces of 1.5-2.5m2 are used , according to the surface patient's body, in our study the size of the dialyzer has been increased in 4 cases of 1.9m2 to 2.1m2 . The changes made in the usual pattern referents at the time of treatment, bath flow, membrane or size of the needles, not only did they recover the doses of Kt that had decreased with the adjustments of the flow but also that dose figures will be reached of dialysis recommended for all patients. It should be borne in mind that our sample is small, so it would be advisable to repeat the study with larger samples to verify the results (26, 28,29).

5. CONCLUSIONS

A decrease in the pump flow that negatively affects the dialysis dose, therefore, it would be necessary to make changes of patterns in an individualized way to recover the lost dialytical effectiveness.

Ethical Approval:

All ethical issues were approved by the author. Data collection and patients enrollment were in accordance with Declaration of Helsinki of World Medical Association , 2013 for the ethical principles of researches involving human. Signed informed consent was obtained from each participant and data were kept confidentially.

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