Spirometry Parameters in Patients Undergoing Hemodialysis With Bicarbonate and Acetate Dialysates

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Introduction. End-stage renal disease causes impairment of all body organs including the heart and the lung. The main problems in the afflicted patients are pulmonary edema due to increased permeability of the capillaries, intravascular and interstitial volume overload, hypertension, and congestive heart failure. These changes cause altered physiologic and mechanical function of the lungs and subsequently increase in airway resistance. We aimed to study the impact of hemodialysis on spirometry parameters.
Materials and Methods. In a cross-sectional study performed on 41 patients on maintenance hemodialysis, spirometry was done before and after the dialysis session. The patients were on either acetate or bicarbonate hemodialysis with the same method, dialysis machine, and duration of dialysis. Alterations in spirometry parameters including forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, and maximal midexpiratory flow rate were determined and their relation with serum electrolytes, serum creatinine, blood urea nitrogen, and hemoglobin were analyzed.
Results. Twenty-nine patients undergoing dialysis with bicarbonate dialysate and 21 on dialysis with acetate were compared. Improvement in spirometry parameters was only significant in patients undergoing dialysis with bicarbonate dialysate. All spirometry parameters showed significant increases in the bicarbonate group except for the FEV1/FVC ratio. Furthermore, significant increase in these parameters was only prominent in the men. Postdialysis weight reduction and laboratory indexes had no significant correlation with improvement of spirometry parameters.
Conclusions. Dialysis with bicarbonate dialysate causes significant improvement in spirometry parameters in men on maintenance dialysis. This effect might be independent of the effect of removing the volume overload by dialysis.

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INTRODUCTION

When blood urea nitrogen level exceeds a distinctive threshold, effects of uremia on respiratory system are evident.[1] These include acute conditions such as acute pulmonary edema, pleural effusion, and acute respiratory distress syndrome (ARDS), and chronic effects such as calcification of the lung tissue and the vascular intima and impaired cardiorespiratory system. Kidney failure impacts directly and indirectly the mechanical function and ventilation of the lungs, treatment with drugs and hemodialysis are responsible for a part of this effect.[2] The main consequences of kidney failure are intravascular and extravascular volume overload and subsequent interstitial pulmonary edema, varying degrees of left-sided heart failure causing arterial hypertension, anemia, hypoalbuminemia, uremic cardiomyopathy, and soft tissue calcification of the lung, vessels, and subcutaneous tissues.[2-7] Also, toxic effects of uremia on the endothelium of the pulmonary capillaries lead to increased permeability of the pulmonary capillary, leading to edema and increased resistance in the small airways and alveoli.[6]

Impairment of the lung function and dyspnea during a session of hemodialysis was first described by Sherlock and colleagues.[4] Factors contributing to this process are the underlying disease, the dialysate used for hemodialysis, and the membrane material and its extent of contact with blood. It seems that this phenomenon could be proportionally due to complement activation and entrapment of the leukocytes that cause pulmonary capillary inflammation and impaired oxygenation which ultimately results in increased airway resistance.[5,6,8,9] Using spirometry, these subtle changes in the air flow can be determined; however, there are few reports on the effects of the above factors on spirometry parameters. We designed a study to address this issue and focused on the effects of dialysates on spirometry parameters.

MATERIALS AND METHODS

Patients

During September and October 2006, this study was conducted on patients with end-stage renal disease undergoing long-term hemodialysis at Shahid Labbafinejad Medical Center in Tehran, Iran. All of the patients on hemodialysis were approached for participation in this study. The inclusion criteria were normal pulmonary features on chest radiography (taken prior to hemodialysis), normal thorax and vertebral column on chest radiography, ability of the patient to perform the spirometry (Karnovsky index greater than 70),[10] age of at least 18 years, and sufficient Kt/V (confirmed by laboratory tests). We excluded patients with any of the following conditions: severe disability and poor compliance, history of chronic pulmonary diseases, kyphoscoliosis or any thorax deformity, acute respiratory infection, acquired immunodeficiency syndrome, hepatitis B infection, hepatitis C infection, cardiac valve disease, decompensated congestive heart failure, arrhythmia, hypertension (> 180/100 mm Hg), or history of cardiac or thoracic surgery. Written informed consent was obtained from the eligible patients.

Hemodialysis

The patients were on 4-hour hemodialysis thrice a week at least for 6 months. They were divided into 2 groups based on the dialysate type (bicarbonate or acetate dialysates). The spirometry operator, the statistician, and the researcher were blinded to the selection of bicarbonate or acetate dialysates which had been done by the nephrologists. Dialysis membrane was identical in all of the patients with an area of 1 m^2 and the material was polysulfane-R5. The hemodialysis machines were manufactured by Fresenius 4008B equipment (Fresenius Medical Care AG, Bad Homburg, Germany). Dialysis was performed alike in all the patients complying with the following criteria: constant blood flow (200 mL/min), constant dialysate flow (500 mL/min), and 4-hour duration of hemodialysis. Postdialysis weight loss was measured and serum levels of calcium, phosphate, urea nitrogen, creatinine, albumin, and hemoglobin were checked.

Spirometry

Spirometry was performed in the patients 15 minutes prior to initiation of a dialysis session. It was done in sitting position with a standard medical international research calibrated machine at 7:30 AM. The procedure was repeated 15 minutes after the dialysis session.

The following spirometry parameters were determined: forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, and maximal midexpiratory flow rate (FEF 25%-75%). Normal changes in respiratory flow in 24 hours are less than 5% for FEV1 and FVC and less than 11% for FEF 25%-75%, which were considered in statistical analyses.[1]

Statistical Analyses

Data were analyzed using the SPSS software (Statistical Package for the Social Sciences, version 11.5, SPSS Inc, Chicago, Ill, USA). Comparisons of the values of spirometry parameters between the groups were done by either the Student *t* test or the Mann-Whitney U test, where appropriate. Correlations between the parameters were tested by the Pearson correlation test and the Spearmen rho test. *P* values less than .05 were considered significant.

RESULTS

Of 80 patients undergoing hemodialysis, 41 were eligible to participate in this study. They were 27 men (65.9%) and 14 women (34.1%), with a mean age of 48.9 ± 25.0 years (range, 19 to 85 years). Bicarbonate dialysate was used in 29 patients (70.7%; 22 men and 7 women), and acetate dialysate in 12 (29.3%; 5 men and 7 women). The median age of the patients with bicarbonate hemodialysis and acetate hemodialysis modalities were 51 years and 42 years, respectively.

Overall, pulmonary function was improved after the dialysis session based on most of the spirometry parameters; however, improvement was significant in the men rather than the women (Table 1). Concerning the patients on hemodialysis with bicarbonate dialysate, improvement in FEV1, FVC, and FEF 25%-75% was significant in the men (Table 2). Other groups, includeing the women and the patients on hemodialysis with acetate dialysate, did not experience a significant change in the spirometry parameters (Table 2).

There was no significant correlation between improvement of spirometry parameters and weight reduction following dialysis or the laboratory test results for serum levels of calcium, phosphate, creatinine, sodium, and potassium. Also, blood levels of hemoglobin and urea nitrogen did not correlate with spirometry parameters before and after dialysis.

Table 1. Spirometry Parameters (Median) Before and After Hemodialysis*

Spirometry Parameters	Estimated Percentage		*P*
	Before Dialysis	After Dialysis	
All Patients			
FEV1	88.8	91.9	.001
FVC	85.2	88.1	.003
FEF 25%-75%	79.9	85.1	.004
FEV1/FVC	104.0	104.0	.94
Men			
FEV1	92.7	96.9	< .001
FVC	88.6	92.1	< .001
FEF25%-75%	86.0	93.4	.001
FEV1/FVC	104.9	105.2	.66
Women			
FEV1	81.2	82.2	.58
FVC	78.7	80.5	.45
FEF25%-75%	67.7	69.0	.68
FEV1/FVC	104.2	103.3	.53

*FEV1 indicates forced expiratory volume in the first second; FVC, forced vital capacity; and FEF 25%-75%, maximal midexpiratory flow rate.

DISCUSSION

Results of the present study showed that hemodialysis in patients with end-stage renal disease causes a relative increase in all spirometry parameters. However, considering analysis of data in each gender, this effect could be observed only in the men, while women experienced nonsignificant increases, or in some cases, a slight decrease in their siprometry parameters after a dialysis session. Concerning the dialysis solutions, we found that increase of spirometry parameters is statistically significant in the group of patients who underwent

Table 2. Spirometry Parameters (Median) Before and After Hemodialysis in Patients With Bicarbonate and Acetate Dialysates*

Spirometry Parameters	Bicarbonate			Acetate		
	Before Dialysis	After Dialysis	*P*	Before Dialysis	After Dialysis	*P*
Men						
FEV1	91.7	95.8	< .001	97.2	102.0	.18
FVC	87.6	91.5	< .001	93.2	94.4	.58
FEF25%-75%	83.9	90.5	< .001	96.0	106.0	.37
FEV1/FVC	104.0	103.0	.42	108.0	116.0	.18
Women						
FEV1	74.4	67.8	.86	85.4	86.7	.62
FVC	71.0	72.9	.74	86.4	88.8	.52
FEF25%-75%	68.5	73.5	.24	67.0	64.7	.65
FEV1/FVC	108	109.0	.57	100.0	97.0	.17

*FEV1 indicates forced expiratory volume in the first second; FVC, forced vital capacity; and FEF 25%-75%, maximal midexpiratory flow rate.

dialysis with bicarbonate dialysate rather than those with acetate dialysate.

In contrast to FEV1, FVC, and FEF 25%-75%, there was no significant changes overall or among the subgroups of the patients in the FEV1/FVC ratio. Results of this study are complementary to some extent with the study done by Kovacevic and colleagues in Bosnia in which they showed significant improvement in pulmonary function of men undergoing bicarbonate hemodialysis according to spirometry parameters.[11] Changes in FEF 25%-75%, however, were not measured in this study. In agreement with our results, they found that neither of the changes in spirometry parameters was the effect of weight reduction after dialysis.

Correlation between weight loss after dialysis and improvement of spirometry parameters is noteworthy and controversial articles are present. Alves and coworkers confirmed that the improvement of spirometry parameters after dialysis significantly correlated with weight reduction after dialysis ($P = .003$).[12] Conversely, Lang and associates from Germany who focused on weight reduction and improvement of spirometry parameters in their recent study, concluded that there was no significant correlation between the improvement of spirometry factors and weight reduction.[13] Ferrer and colleagues reviewed the phenomenon of improvement in pulmonary function after dialysis and showed that hyperreactivity of the airways was not different in these patients from that in the healthy individuals.[14]

It seems these results are controversial because of the type of the study, patients selection, and setting of the study. Selection of incongruent patients according to the underlying disease and hemodialysis efficacy could lead to this discrepancy in studies. Differences in hemodialysis procedure charactreistics, size and type of dialysis filter, and duration of dialysis could be associated with contradictory results. Comprehensive studies are recommended to confim our results, as we had a small sample of patients.

CONCLUSIONS

In brief, comparison of the results of our study with those previously performed can yield the following conclusions: it is evident that hemodialysis causes improvement in pulmonary function of hemodialysis patients. Other than the possible effect of removing the excessive water accummolated in the body, it seems that other factors such as the type of dialysis solution have a role in the alterations in spirometry parameters in patients on hemodialysis. Also, geneder difference was an interesting finding of our study; improvement of pulmonary function was more prominenet in the men than that in the women, which could be probably due to muscle weakness seen more frequently in the women.

We can speculate that in patients with adequet dialysis, weight reduction in the course of hemodialysis has no effect on the improvement of pulmonary function, while the opposite can be observed in patients with acute kidney failure who undergo hemodialysis. According to these results, a more specific investigation on greater number of patients especially with diagnostic instruments such as maximal inspiratory pressure is anticipated to lead to more helpful findings.

CONFLICT OF INTEREST

None declared.

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