PEAK EXPIRATORY FLOW RATE AND ARTERIAL BLOOD GAS CHANGES DURING HEMODIALYSIS OF PATIENTS WITH CHRONIC RENAL FAILURE

Sevda ÖZDOĞAN, M.D., Haluk TÜRKTAŞ, M.D.

Gazi University, Faculty of Medicine, Department of Chest Diseases, Ankara, Turkey
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SUMMARY : *In a group of 22 patients, peak expiratory flow rate (PEFR) and arterial blood gas tensions were measured with regular intervals during a hemodialysis session where cuprofan membrane and acetate buffered dialysate were used. There was a significant decrease in arterial oxygen tension (PaO_2) and a significant increase in arterial pH from predialysis values during the session, but no significant change was recorded in PEFR.*

Key Words : *Hemodialysis, Peak Expiratory Flow Rate, Blood Gas.*

INTRODUCTION

Hemodialysis is the process of diffusion across a semipermeable membrane to remove undesired substances from the blood while adding desirable components. Several types of membranes such as cellulose acetate, cuprophane, polyacrinonitryl, polymethylmetacrilate or polysulphone are used for the process (Wyngaarden, 1988). A constant blood flow on one side of the membrane and a cleansing solution (dialysate) on the other allows removal of the waste uremic products in a way similar to glomerular filtration (Wilson, 1991).

Hemodialysis effects the pulmonary functions, blood gas tensions and cellular components such as platelets and polimorphonuclear leukocyts in association with the dialyser and dialysate used. Also there have been single case reports of patients who developed bronchoconstriction during hemodialysis (Basile, 1989; Poothullil, 1975). Several reports insist on that the condition is most frequently seen when cuprophane dialyser is used in conjunction with acetate buffered dialysate (Davenport, 1988, 1990; Ei, 1979).

This study was undertaken to enlighten this condition. Changes in peak expiratory flow rate (PEFR) and arterial blood gas tensions were evaluated during a hemodialysis session of the patients treated in the hemodialysis unit of Gazi University Faculty of Medicine.

MATERIALS AND METHODS

A total of twentytwo patients who attended the hospital hemodialysis ward regularly between the 1st and 28th of February 1991 were enrolled in the study. The ones who had renal failure associated with a systemic disease such as polyarteritis nodosa or systemic lipus erythamatosus were excluded.

Gambro DFC-10-2C (Gambro AB, Lund, Sweden) and Fresenius A 1008 D (MTS, Schweinfurt, Germany) type artificial kidney machines were used. They had a 1 m^2 flat plate cuprophane dialyser and dialysate buffered with 38 mEq/L acetate. Both the dialyser and blood lines had been sterilized with % 1 sodium hypochlorite solution and saline.

Patients answered a detailed questionnaire about any past history of allergic phenomena, smoking habits, respiratory symptoms or complaints during dialysis. Each patient was instructed in the use of a Wright mini peak flow meter, and measurements were recorded immediately before the patient was connected to the extracorporeal circuit, and at 30, 60 and 180 minutes after the start of the dialysis provided that the posture was same each time. The maximum PEFR value of three efforts was recorded.

Blood samples were withdrawn before dialysis and at 30, 60 and 180 minutes during dialysis. For measurements of total blood count with peripheral eosinophil count, Contraves digicell 3100 h, haemocell 400 h, trombocell 1000 (Contraves, Switzerland) counters were used. Kinetic turbidimetric method using Behring Turbitimer (Behringwerke AG, W Germany) and Turbiquant antiserum solution (Hoechst-Behring, W.Germany) were used for total C3 and C4 (complemants) determinatîons of the blood samples.

In 18 out of 22 patients arterial blood gas and pH determination could be performed at the beginning, 30, 60 and 180 minutes during dialysis by AVL 995 (AVL LIST GmbH Medizin technick, Austria) Blood Gas Analyser.

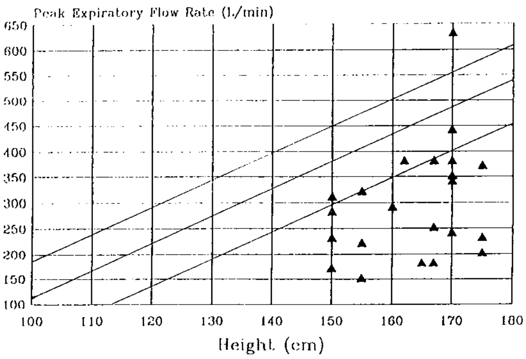
Statistical analysis was made by Student's paired t test.

RESULTS

The mean age of the 22 patients (9 women, 13 men) treated in the hemodialysis department of Gazi University Faculty of Medicine was 47.6 ± 15.2 (min 19-max 68). They had been receiving dialysis treatment for a mean of 25 months (min 1.25-max 84 months) and the mean duration of dialysis during the study was 3.8 hours. Seven of the 22 patients were current cigarette smokers and three were ex-smokers. Three patients complained of a regular cough but the remaining 19 patients did not have any complaints fulfilling the criteria for chronic obstructive pulmonary disease. No patient had a history of asthma or any other atopic disease. Family histories were also negative for allergic diseases and no patient was receiving corticosteroid or bronchodilator treatment. All 22 patients had normal peripheral blood eosinophil percentage with a mean value of % 4.12 ± 2.05. The mean blood flow through the dialyser was 118.86 ml/min (45-265 ml/min) and mean venous pressure was 92.72 mm Hg (0-200 mm Hg) during the session. Throughout the study no patient complained of shortness of breath and the mean weight loss was 1.68 kg.

The mean PEFR (296.36 L/min) of the patients before the dialysis was significantly less than the predicted values (Graphic 1) but no statisticaly significant difference was recorded in PEFR values during the session (Table 1).

In table 2 and table 3 changes in mean neutrophyl and platelet counts during the session are se-



Graphic 1 : Predialysis PEFR values against standart normal population.

Minute	Mean	St Deviation
0	296.36 L/min	± 110.82
30	300.91 L/min	± 100.23
60	305.0 L/min	± 101.22
180	314.09 L/min	± 111.98

Table - 1 : Mean peak expiratory flow rates (PEFR) recorded during hemodialysis (n=22 p>0.05).

Minute	Mean	St Deviation
0	3630.91 / mm3	± 1373.83
30	3315.91 / mm3	± 1605.51
60	4338.18 / mm3	± 1541.09
180	4093.18 / mm3	± 1172.85

Table - 2 : Mean white blood cell values recorded during hemodialysis (n=22).

Minute	Mean	St Deviation
0	175681.82 / mm3	± 41042.82
30	175409.09 / mm3	± 45634.84
60	186136.36 / mm3	± 50891.38
180	184454.55 / mm3	± 63264.16

Table - 3 : Mean platelet values recorded during hemodialysis (n=22).

en. Significant change was only recorded between the beginning and 60 minute values ($p<0.05$).

There were no significant changes in either serum total C3 or total C4 of the patients (Table 4, 5).

In 18 patients out of 22, arterial blood gas analysis could be performed. In arterial partial oxygen pressure (PaO_2) there was a significant decrease and in pH a significant increase by 30 minutes of the session (Graphic 2, 3). No significant change was recorded in arterial partial carbondioxide pressure ($PaCO_2$) (Table 6).

Minute	Mean	St Deviation
0	59.81 mg/dl	± 21.85
30	62.28 mg/dl	± 22.69
60	56.77 mg/dl	± 19.61
180	61.13 mg/dl	± 20.86

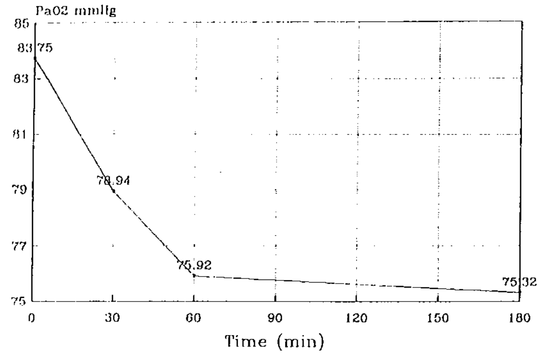
Table - 4 : Mean total C3 values during hemodialysis (n=22 p>0.05).

Minute	Mean	St Deviation
0	26.54 mg/dl	± 12.18
30	26.68 mg/dl	± 10.96
60	27.30 mg/dl	± 12.77
180	27.94 mg/dl	± 12.23

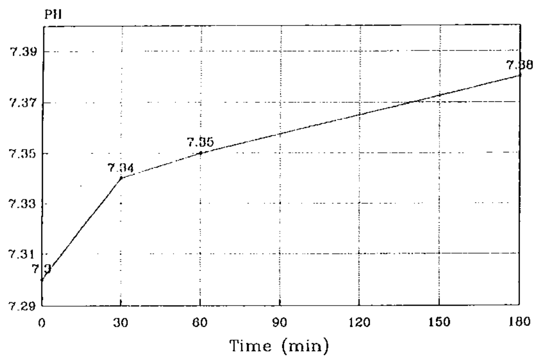
Table - 5 : Mean total C4 values during hemodialysis (n=22 p>0.05).

Minute	Mean	St Deviation
0	30.77 mm/Hg	± 4.08
30	30.17 mm/Hg	± 2.55
60	33.19 mm/Hg	± 3.77
180	32.66 mm/Hg	± 3.86

Table - 6 : Mean PaCO2 recorded during hemodialysis (n=18 p>0.05).



Graphic 2 : Mean PaO2 values during hemodialysis (n=18 p<0.05).



Graphic 3 : Mean PH values during hemodialysis (n=18 p<0.05)

DISCUSSION

In patients with chronic renal failure, impairment in respiratory muscle function, pulmonary mechanics and gas exchange can be determined. In pulmonary function test, signs of restrictive disease and small airway obstruction can be observed in the absence of a clinically determined cardiopulmonary disease (Zidulka, 1973). Treatment with hemodialysis also causes intrapulmonary leucostasis, hypoxemia, ventilation-perfusion mismatch and irregular breathing. Most of these adverse reactions have been reported to occur more frequently when cuprophane dialyser is used in conjunction with acetate buffered dialysate (Berlo, 1988; De Backer, 1983; Kolb, 1988; Sengbusch, 1989).

Patients with chronic obstructive pulmonary disease (COPD) are expected to be more vulnerable to the abnormalities in respiratory system during hemodialysis (Pitcher, 1989).

Acute hypoxemia occurs shortly after the beginning of hemodialysis. In our study approximately 8 mm Hg reduction in PaO_2 has been detected. Mechanisms proposed for hemodialysis associated hypoxemia are 1-pulmonary microembolization, 2- activation of the complement system and altered ventilation / perfusion ratio, 3- hypoventilation caused by CO_2 unloading during acetate dialysis and 4- direct effect of acetate on respiratory center (Aurigemma, 1977; Bischel, 1975; Cohen, 1988; De Broe, 1989; Dumler, 1979). Davenport and co workers also suggest that bronchoconstriction might also contribute to dialysis induced hypoxemia (Davenport, 1988).

Peak expiratory flow rate is the maximum flow reached during a forced expiratory maneuver and this parameter can be measured practically by the help of a small portable flow meter (Ruppel, 1979). Similar to the results of Davenport and co workers, predialysis PEFR values of our patients were below the predicted values calculated according to their age, sex and height. Impaired respiratory muscle function in patients with chronic renal failure is expressed as significant decrease in the strength of the respiratory muscles measured by the maximal static inspiratory and expiratory pressures (Bark, 1988). So, low predialysis PEFR values of our patients may be due to uremic myopathy or peribronchial edema but no significant difference was recorded in PEFR values during the hemodialysis session and no patient complained of any shortness of breath.

PEFR recorded during a forced expiratory maneuver is dependent not only on airway caliber but also on respiratory muscle strength and the patient's effort. Thus changes in peak flow must be considered by suspect if the patient has lability of muscle strength or motivation (Beauchamp, 1989; Göloğlu, 1987; Prezant, 1990). The best way to determine the condition of airways is to get a complete flow volume profile, instead of a peak flow measurement alone.

Kazan and co workers have determined an increase in the first second forced expiratory volume (FEV1) and forced vital capacity (FVC) at the end of a hemodialysis session (Kazan, 1981). Their results can be accepted as a clue against bronchoconstrictive effect of hemodialysis.

During hemodialysis, albumin, complement components and fibrin are deposited on the surface of the dialyser membrane and reuse of the same dialyser after cleaning with 1 % sodium hypochlorite has been shown to reduce complement activation and expected reduction in PEFR (Davenport, 1990). These results suggest that reprocessing the dialyser membrane alters its biocompatibility characteristics. We did not observe any significant difference in PEFR, in neutrophil and platelet counts in our study and this may be the result of the improvement in biocompatibility of the dialyser membrane after cleaning with sodium hypochlorite.

In the complement system, C3 is activated by both the classical and alternative pathways whereas C4 is activated only by classical pathway. Membrane bioincompatibility during hemodialysis results in the activation of alternative pathway of the complement system (Cheung, 1989; Hakim 1984). We did not observe any significant change in total C3 of the patients during hemodialysis but our technical capabilities did not let us measure the active metabolites such as C3 desarginin. Several reports indicate that blood C3 des-arginin level is significantly increased during hemodialysis (Hakim, 1984).

Chronic renal failure patients show respiratory compansated metabolic acidosis at the beginning of dialysis and blood pH reverts to alkalosis towards the end of the session without any diffeence in $PaCO_2$ (Cohen 1988, De Broe, 1989). We observed similar increase in pH during the hemodialysis in our patients also.

When the patients is dialised against a bath containing acetate, the PCO_2 in the blood returning to the patient is very low because of the acetate metabolism. This low PCO_2 stimulates the respiratory center causing alveolar hypoventilation and arteriolar CO_2 pressure ($PaCO_2$) remain constant (De Broe 1989).

In our study, we did not observe any clinical sign of bronchoconstriction or decrease in PEFR during a dialysis session in which cuprophane dialyser and acetate buffered dialysate is used. As mentioned before, PEFR alone is dependent not only on airway calibre but also on respiratory muscle strength and the patient's effort, so this result should be supported by a study where complete flow volume profile is available.

Hemodialysis associated hypoxemia may be of clinical importance in patients with compromised cardiorespiratory function. Such high risk patients should be followed intensively with additional O_2 supply whenever indicated. Patients with a compromised cardiopulmonary function should preferentially be dialyzed with a more biocompatible membrane and dialysate.

Correspondence to : Dr.Haluk TÜRKTAŞ
Gazi Üniversitesi Tıp Fakültesi
Göğüs Hastalıkları Anabilim Dalı
Gölbaşı
06830 ANKARA - TÜRKİYE
Phone : 4 - 484 10 96

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