Original Paper

EFFECT OF SURFACE AREA OF DIALYZER MEMBRANE ON THE ADEQUACY OF HAEMODIALYSIS

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Abstract

Introduction: **Patients with end stage renal disease require 12 hours of haemodialysis per week in three equal sessions (4 hours/day for 3 days/week). But the duration and frequency of treatment can be reduced by increasing the surface area of the dialyzer membrane.**

Methods: **In this prospective study 40 patients of end stage renal disease receiving haemodialysis for more than six months were included to observe the effects of increment in the surface area of the dialyzer membrane on the adequacy of haemodialysis.**

Result: **It was observed that 20 patients receiving haemodialysis on a dialyzer with membrane surface area of 1.2 m² did not have satisfactory solute clearance index. Urea reduction ratio was 45.9 ± 3.03 and fractional urea clearance (Kt/V) was 0.76 ± 0.09. On the other hand patients (20 cases) receiving haemodialysis on a dialyzer with membrane surface area of 1.3 m² had a urea reduction ratio 50.76± 5.16 and fractional urea clearance (Kt/V) 0.91 ± 0.16. All the patients of both groups received dialysis for 8 hours/week in two equal sessions (4 hours/day for 2 days/week). Statistically the increment was significant (p<0.001).**

Conclusion: **This study reveals, adequacy of dialysis can be increased by increasing the surface area of the dialyzer membrane. So, considering the poor socio-economic condition of Bangladesh and patients' convenience, a short duration, low cost dialysis regime can be tried by increasing the surface area of dialyzer membrane.**

Keywords: **Haemodialysis, dialyzer membrane, duration**

Introduction

With the availability of Haemodialysis (HD) the lives of thousands of patients with end stage renal failure (ESRD) has been prolonged. The procedure consists of pumping of heparinazed blood through a dialyzer at a flow rate of 300 to 500 ml/min while dialysate flows in opposite counter current direction at 500 to 800 ml/min. The clearance of urea ranges from 200 ml to 300 ml/min. The efficiency of dialysis is determined by blood and dialysate flow rate as well as the dialyzer characteristics. The dose of dialysis is defined as the magnitude of urea clearance during a single treatment and the dose of dialysis is correlated with patient's mortality and morbidity[1]. The current measures of dialysis as guided by the United State National Kidney Foundation Dialysis Outcome Quality Initiative (NKF-DOQI) are treatment related Urea reduction ratio (URR) and fractional urea clearance (Kt/V)[2]. URR is a quantitative measurement of an individual patient's urea clearance during a dialysis session[3] and Kt/V is the ratio between the volume of blood cleared during a dialysis session (Kt) & the distribution volume of urea within the patient. Both are calculated from blood urea measurement, where K represents the dialyzer urea clearance (ml/min), 't' is the treatment time & `V' is the body urea distribution volume (ml). The current dialysis adequacy standard in the United States, as set up by DOQI guidelines, recommends to keep Kt/V greater then 1.2, which corresponds to a URR of 65%[2]. There are five primary treatment variables that determine the actual dose of dialysis. These are: blood flow rate, dialysate flow rate, composition of dialysate fluid, duration of treatment & composition and surface area of dialyzer membrane[4].

When the other variables are constant the dose of haemodialysis can be increased by increasing the surface area of the dialyzer membrane. The ability of a dialyzer to remove small molecular weight solutes, such as urea is primarily a function of its membrane surface area. A high efficiency dialyzer is basically a big dialyzer (surface area >1.5 m^2). By virtue of its high surface area, it has a high ability to remove urea[2]. Square meter hour hypothesis relate the efficiency of dialysis in preventing the development of neuropathy to the number of hours of dialysis per week and the active membrane surface area[5]. Hakim et al[6] suggested that delivered dose of dialysis can be improved by selecting dialyzer with a large surface area. Panagoutusos et al[7] showed improvement in adequacy, in those receiving haemodialysis by increasing the surface area of the dialyzer membrane. Owen et al[3] concludes that improvement of solute clearance as well as nutritional status of haemodialysis patients can be achieved by increasing the time of haemodialysis and using more efficient dialyzer. Present study was conducted to evaluate the impact of

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surface area of the dialyzer membrane on adequacy of haemodialysis in Bangladeshi patients.

Materials and Methods

A total of 40 clinically diagnosed ESRD patients of both sexes (irrespective of aetiology) receiving HD for more than 6 month were included in this study. All the patients had arterio-venous (A-V) fistula on the wrist or elbow. Patients were selected from the haemodialysis units of Bangladesh Institute for Research in Diabetes, Endocrine and Metabolic diseases (BIRDEM) and Bangabandhu Sheik Mujib Medical University (BSMMU), Dhaka. The patients were grouped into group-A & group-B according to the surface area of the dialyzer membrane. Patients receiving HD on a dialyzer with 1.2 m^2 surface area were categorized as group-A and those receiving HD on a dialyzer with 1.3 m^2 surface are were categorized as group-B. Dialysate flow rate was 500ml/min and mean blood flow rate was 250 ml/min. Blood was collected aseptically before HD from the A-V access through arterial needle and subsequently 30 min after completion of HD from another hand to avoid the risk of post dialysis urea rebound and access recirculation. Serum urea level was estimated by Berthelot method and URR (urea reduction ratio) was calculated by the following formula;

$$URR = \frac{\text{Pre-dialysis urea (mg/dl)} - \text{Post- dialysis urea (mg/dl)}}{\text{Pre-dialysis urea (mg/dl)}} \times 100$$

There are several methods for calculation of Kt/V. Kovacic et al[8] advised to use simple non logarithmic Barth formula for calculation of Kt/V. Modified formula (Barth formula-percent reduction of urea method)[9] = 0.031x[(c1- c2/c1) x100]-0.66 (c1= Pre-dialysis blood urea concentration, c2= Post-dialysis blood urea concentration). Above parameters were repeated at 4 weeks interval for reproducibility. Data were analyzed in tabulated form and student's t test was done to observe the significance level of differences.

Results

After HD both groups showed significant ($p<0.001$) reduction of mean serum urea level (Table-I). The mean ± SD values of URR and Kt/V of group B were more (table-II). The values were analyzed by unpaired t test and the difference of values between the two were found to be highly significant ($p<0.001$).

Table-I: Pre- and post-dialysis serum urea level

Groups	Pre-dialysis (mg/dl)	Post-dialysis (mg/dl)	p- value
Group – A (n=20)	106.7±8.92	57.70±6.42	<0.001
Group – B (n=20)	123.8±10.0	60.75±5.09	<0.001

Table -II: Solute clearance indices among the study groups.

Parameters	Group A (n=20)	Group B (n=20)
URR	45.9±3.03 %	50.67±5.16%
Kt/V	0.76±0.09	0.91±0.16

Discussion

Measuring the adequacy of HD is not an easy task. There is no objective, reliable and universally accepted criteria for measuring the adequacy. In this cross over study to asses the effect of surface area of dialyzer membrane on the adequacy; the solute clearance indices (URR and Kt/V) of the study subjects were measured. NKF-DOQI guide lines recommend URR greater than 65% and Kt/v greater than 1.2 which is associated with lower rate of mortality and morbidity[10]. HD for 12 hours/week (4 hours/day for 3 days/week) is the standard and widely accepted regime to achieve adequate HD. But there is a tendency to shorten dialysis time to reduce cost and to increase patients' convenience. In Bangladesh each HD session costs about Taka 2000, which is too expensive. ESRD patients in this country prefer 2 days/week HD due to their poor socio-economic condition and suffer from various complications due to inadequate removal of uremic toxins. To overcome this problem, studies were conducted to increase the adequacy of dialysis by increasing the surface area of the dialyzer membrane, without increasing the time and frequency of dialysis. In this study, group A patients were dialyzed on a dialyzer with surface area of 1.2 m² and group B patients the surface area of the dialyzer membrane was increased to 1.3 m² but the time of dialysis was same in patients of both groups (8 hours/week i.e. 4 hours/day for 2 days/ week).

In group A patients mean±SD values of URR and Kt/v were 45.9 ± 3.03 and 0.76±0.09 respectively. In group B patients these values were 50.67±5.16 and 0.91±0.16 respectively. By comparing it was observed that in group B patients the URR was 10.4% higher and Kt/V was 19.7% higher than those of group A patients. These differences were found to be statistically significant ($p<0.001$). So solute clearance of group B patients were better than those of group A patients. Panagoutsos et al[7], in their study, increased the surface area of the dialyzer membrane from 1.15m² ±0.1 to 1.7 m² and found that the Kt/V was increased from 0.93±0.19 to1.55±2.9 ($p<0.05$) and URR were increased from 52±8% to 71±7% ($p<0.05$), that is there was 66.7 % and 36% increment in Kt/V and URR respectively.

Conclusion

Adequacy of dialysis can be increased by increasing the surface area of the dialyzer membrane. Considering the poor socio-economic condition of Bangladesh and patients' convenience, a short duration, low cost dialysis regime can be tried by increasing the surface area of dialyzer membrane.

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