

Effect of Dialyser Reuse on the Efficacy of Haemodialysis in Patients of Chronic Kidney Disease in Developing World.

H.K. Aggarwal, Deepak Jain, Amrish Sahney, Teena Bansal, R.K. Yadav, K.L. Kathuria

Department of Medicine, Division of Nephrology,
Pt. B.D. Sharma University of Health Sciences, Rohtak-124001 (Haryana) India

Abstract: Haemodialysis (HD) is the mainstay of renal replacement therapy in developing world. Due to economic constraints, dropout rates are very high. The current economics of dialysis is back breaking for the average Indian. Effective reuse of dialysers for haemodialysis can help in bringing down the cost of hemodialysis. The dialyser reuse is still infrequent in developing countries like India with hot climatic conditions because of fear of infections. This study was undertaken to know whether dialyser reuse is cost effective and safer option in developing countries like India. This prospective study included twenty five end stage renal disease patients on maintenance dialysis, on at least twice weekly haemodialysis. Each patient was dialysed thrice using same dialyser after reprocessing with formaldehyde 4%. After each session blood urea, post dialysis weight, serum calcium and phosphate, and serum albumin were measured. Kt/V and urea reduction ratio (URR) were calculated as measure of dialysis adequacy. Before the start of dialysis session baseline TCV (total cell volume) of dialyser was calculated. The dialyser was discarded, if TCV fell below 80% of baseline value.

The mean age of the patients was 43.88 ± 2.3 years. There were 16 males. The mean baseline total cell volume (TCV_b) was 84.37 ml, and means total cell volume at second (TCV₂) and third use (TCV₃) were 81.08 ml and 78.95 ml respectively. Total cell volume after reuse never fell below 80% of baseline TCV. The calculated mean Kt/V after first dialyser use (i.e. 1.28 ± 0.06) was compared with that after second and third use (i.e. 1.29 ± 0.07 and 1.24 ± 0.04) respectively and p values of no statistical significance ($P > 0.05$) were obtained. URR after first dialyser use (i.e. $65.82 \pm .01$), was compared with URR after second and third use (i.e. 65.59 ± 0.02 and 65.95 ± 0.02) and p values of no statistical significance ($P > 0.05$) were obtained. No patient developed any intradialytic symptoms. The study also observed a cost saving of Rs.285 per dialysis session. The present study showed that use of same dialyser up to three times was effective and safe. Further, it was cost effective without jeopardising patient's safety. Therefore, in Indian scenario, the dialyser reuse should be encouraged which is likely to go a long way in preventing patients dropout from dialysis programme.

Key words Chronic kidney disease, Haemodialysis, Dialyser reuse.

INTRODUCTION

Chronic kidney disease (CKD) is a devastating disease with medical, social and ethical implications and is emerging as a major health problem globally. Incidence of CKD has doubled in last fifteen years.¹ There are approx. 7.85 million CKD patients in India with an annual incidence of one lac.² In India, patients with CKD generally present late in course of disease, with 66 percent first seeing nephrologists when they are already in ESRD.³ Haemodialysis (HD) is the mainstay of RRT in India. Whereas GNP is about \$430 annually, the cost of dialysis is estimated at \$700 monthly. Due to economic constraints, dropout rates are very high especially within first 3 months of haemodialysis treatment programme.⁴ The problems of poverty and malnutrition cannot be solved easily but effective reuse of dialysers for haemodialysis can help in bringing down the cost of hemodialysis. Dialyser reuse has been practiced since the beginning of chronic hemodialysis, because of the economic savings associated with dialyser reuse. Dialyser reuse has been increasingly practiced in the developed world with cold climatic conditions, primarily as an approach to reduce cost. However the dialyser reuse is still infrequent in developing countries like India with hot climatic conditions because of fear of infections. Studies of efficacy and safety of dialysis using reused dialysers have shown mixed results with few studies showing a centre specific effect of reuse on delivered dialysis dose and others reporting it as safe and effective. This study was undertaken to know whether dialyser reuse is cost effective and safer option in developing

countries like India.

MATERIALS AND METHOD

This prospective study was conducted during the year 2009, involving twenty five ESRD patients on maintenance dialysis attending 'kidney and dialysis Clinic' of Post Graduate Institute of Medical Sciences, Rohtak. HIV and HBsAg negative patients having ESRD, on at least twice weekly haemodialysis with vascular access yielding at least 250-300 ml per min blood flow were included in the study. Each patient was dialysed thrice using same dialyser after reprocessing with formaldehyde 4%. F-6 polysulfone dialyser with surface area of 1.3 m² was used for the study. Anticoagulation was maintained by a loading dose of heparin 5000 IU followed by hourly boluses, to maintain the activated clotting time at 1.5 times the baseline. Each dialysis session lasted for four hours. All the patients were monitored for any intradialytic symptoms (i.e. fever, sweating, rigors, nausea/vomiting, chest pain and hypotension) during dialysis session. After each session blood urea, post dialysis weight, serum calcium and phosphate, and serum albumin were measured. Kt/V and URR were calculated as measure of dialysis adequacy.

Before the start of dialysis session baseline TCV (total cell volume) of dialyser was calculated. After each session, patient's dialyser was reprocessed. Manual method of reprocessing was followed, using Hydrogen peroxide 3% as cleansing agent and 4% formaldehyde as disinfectant.

The total cell volume (TCV) was calculated using

sphygmomanometer. The dialyser was discarded, if TCV fell below 80% of baseline value. Each Dialyser was labeled with the patient's name, registration number, and number of use and was stored in plastic bag at room temperature until subsequent dialysis session. During priming for subsequent dialysis the dialysate compartment was filled heparinised saline, the tubings connected, and dialysate circulated at 500 ml per min. formaldehyde was removed from the circuit using 3 liters of heparinised saline until effluent gave reading of trace or less on serum reagent test strips.

Estimation of URR and Kt/V⁵

URR was calculated using following formula:

$$URR = [(U_{pre} - U_{post}) / U_{pre}] \times 100$$

Where, U_{pre} and U_{post} are predialysis and postdialysis urea level respectively.

Kt/V was calculated by using Daugirdas 2nd generation formula.

$$Kt/V = -\ln [R - 0.03] + [4 - 3.5R] \times UF/w$$

Where, R=Post BUN/Pre BUN; UF=Achieved ultrafiltration.; w= Post dialysis weight.

The URR and Kt/V after first dialyser use was compared with that of second and third use. The student 't' test was used for statistical analysis of results.

The mean serum calcium and phosphate, and albumin levels after first, second, and third use were compared using Anova test.

RESULTS

There were total of twenty five ESRD patients included in the study, out of which 16 were males. The mean age of the patient was 43.88 ± 2.3 years. The age profile of the patients showed that 68% of the patients were below 50 years of age. Each patient was dialysed thrice using the same dialyser after reprocessing with formaldehyde 4%. The mean baseline total cell volume (TCV_I) was 84.37 ml, and means total cell volume at second (TCV_{II}) and third use (TCV_{III}) were 81.08 ml and was 78.95 ml respectively. These observations reveal that mean TCV_{II} and TCV_{III} were 96 and 94 percent respectively of mean baseline TCV. Hence, total cell volume after reuse never fell below 80% of baseline TCV. No dialyser was found to have any visual clots or discoloured fibers and hence, no dialyser was discarded during reprocessing procedure.(Table-1)

The delivered dose of dialysis was calculated as Kt/V and URR after

Table 1: Dialyser Characteristic and Total Cell Volume (TCV)

Dialyser used	F-6
Surface area	1.3 m ²
Membrane type	Polysulfone
baseline TCV _I (TCV before 1 st use)	84.375 ml
TCV _{II} (at 2 nd use)	81.08 ml
TCV _{III} (at 3 rd use)	78.95 ml
Dialyser clotted	Nil
Dialyser discarded	Nil

each dialysis session. The study observed that mean Kt/V and URR after total (i.e. 75) dialysis sessions were 1.24 ± .06 and 65.24 ± 0.15 respectively. These observations are in accordance with K-DOQI guidelines of Kt/V more than 1.2 and URR more than 65, for effective dialysis dose in patients on maintenance haemodialysis. Table III shows comparison of delivered dose i.e. Kt/V and URR after first dialyser use with second and third use. The calculated mean Kt/V after first dialyser use (i.e. 1.28 ± 0.06) was compared with that after second and third use (i.e. 1.29 ± 0.07 and 1.24 ± 0.04) respectively by applying student 't' test and p values of no statistical significance (P> 0.05) were obtained. URR after first dialyser use (i.e. 65.82 ±

.01), was compared with URR after second and third use (i.e. 65.59 ± 0.02 and 65.95 ± 0.02) by applying student 't' test and p values of no statistical significance (P> 0.05) were obtained, again indicating that, the efficacy of dialysis is maintained with up to three uses of same dialyser. (Table-2)

Table 2: Delivered dialysis dose Kt/V and Urea Reduction ratio (URR) of New and reused dialyser.

Use of dialyser	no of patients	Kt/V mean ± SD	URR mean ± SD
I	25	1.28 ± 0.06	65.82 ± .01
II	25	1.29 ± 0.07	65.59 ± 0.02
III	25	1.24 ± 0.04	65.95 ± 0.02

The study observed no significant difference in mean serum calcium and phosphate levels before and after dialyser reuse. The reduction in mean phosphate level was 0.45 mg/dl after 1st session of dialysis and was maintained at this level after each session. Hence clearance of small molecule like phosphate was not affected with dialyser reuse. The mean serum albumin level at base line was 2.62 ± .23 g/l and that at the end of study was 2.61 ± .27 g/l. There was no significant difference (p>0.05) in serum albumin levels before and after reuse of dialyser. (Table-3)

Table 3: Ca²⁺, PO₄³⁻ and Serum Albumin levels at baseline and after reuse of dialyser.

	Ca ²⁺ Mean ± SD mg/dl	PO ₄ ³⁻ Mean ± SD mg/dl	S. Albumin Mean ± SD g/l
Baseline	8.03 ± 0.42	8.27 ± 0.66	2.62 ± .23
I use	8.10 ± 0.36	7.78 ± 0.60	2.60 ± .26
II use	8.12 ± 0.37	7.37 ± 0.59	2.57 ± .24
III use	8.09 ± 0.26	6.90 ± 0.45	2.58 ± .27
P value (Anova)	0.35(NS)	0.56(NS)	0.73(NS)

All the patients were observed for intradialytic symptoms like fever, sweating, rigors, nausea/vomiting, chest pain and hypotension during each session of dialysis. None of the patient had fever and rigors during first and second session of dialysis, while one patient had fever with rigors during third dialysis session. The fever lasted for 30 to 40 minutes during dialysis session. Patient was thoroughly examined and was found to have diabetic foot and was treated accordingly. Two patients had hypotension during first dialysis session and one patient during second and third sessions. No difference was observed in frequency of nausea/vomiting in patient undergoing reuse of dialyser. No patient had sweating and chest pain while undergoing haemodialysis, during any session. The monthly culture of treated water was found to be negative during the study period. The study also observed that the cost of first use of F-6 dialyser was Rs.927 and that of reuse per session was Rs.642 thus leading to a cost saving of Rs.285 per dialysis session. (Table-4).

Table 4: Material cost of new and reused dialyser.

MATERIAL	F-6 NEW (Rs)	F-6 REUSED (Rs)
Dialyser	650	325
Dialyser tubings	150	150
Acetate solution	75	75
IV sets	12	12
One Heparin vial	40	40
Hydrogen peroxide 3%	0	10
Formalin 4%	0	20
Reagent strip	0	10
Total	Rs 927	Rs 642

DISCUSSION

In the present study, Kt/V and URR were studied as a measure of adequacy of dialysis. The mean Kt/V (i.e. delivered dialysis dose) and URR of 75 sessions of dialysis were 1.24 ± 0.06 and 65.24 ± 0.15 respectively which is as per NKF-K/DOQI recommendations. Only during two dialysis sessions it was less than the recommended value of 1.2. Inadequate HD can increase the risk of mortality and morbidity and also result in malnutrition, functional impairment and anemia.⁶ In large cross sectional studies, mortality of patients on maintenance of haemodialysis increased when Kt/V and urea reduction ratio fell below 1.2 and 65% respectively.⁷ Owen et al in their retrospective study concluded that URR of <60.0% was associated with increased mortality.⁸

The calculated Kt/V after first dialyser use was compared with that after second and third use and p value of no statistical significance ($p > 0.05$) was obtained. Thus the study showed no significant differences in the adequacy of dialysis with up to three uses of same dialyser.

Studies of adequacy and safety of dialysis using re-used dialysers have yielded equivocal results and a centre specific effect of reuse on delivered Kt/V has been noted raising concerns, about monitoring the reuse process. Lobo et al in a prospective study on dialyser reuse reported no significant difference between Kt/V obtained by use of F-6 dialyser up to 6 times.⁹ In the another study by, Manandhar et al the cellulose acetate dialysers were used and reprocessed manually up to 9 times. The study reported that when mean Kt/V after first use was compared with that after seventh, eighth, and ninth use, there was no significant difference obtained.¹⁰ Ahmed et al in the prospective study on dialyser reuse reported that dialysis efficacy (Kt/V > 1.2) was maintained up to 13 reuses.¹¹ Sherman et al in the prospective study on dialyser reuse, compared the Kt/V urea value of dialyser with the most prior uses (mean= 13.8) with that of the dialyser with the lowest number of reuses (mean=3.8). The study reported that dialyser reuse reduces dialysis delivery and the effect appears to be related to the specific methods and procedures of individual dialysis centers.¹² The present study showed no significant difference in efficacy of dialysis with the use of same dialyser upto three times.

Present study also showed that there was no significant difference ($p > 0.05$) in serum albumin levels before and after reuse of dialyser. Hence the study shows that there was no significant albumin leak with dialyser reuse. Similar observation have been made by Ahmed et al, who reported that there was no significant difference in serum albumin levels before and after reuse of dialyser up to 13 times.¹¹

The essential function of a haemodialyser is to permit the mass transfer of solutes from the patient's blood into the dialysate in order to deliver the prescribed hemodialysis treatment. The solute transport capacity or clearance of a haemodialyser is a critical variable in delivering an adequate treatment. For this reason, an accurate assessment of the solute clearance of the haemodialyser is needed. In the absence of direct measures of solute clearance, changes in the TCV (total cell volume = volume of saline necessary to fill the blood compartment of the haemodialyser), also described as the fiber bundle volume (FBV), have been shown to be an adequate index of changes in solute transport characteristics for hollow fiber dialysers.¹³

There have been certain concerns about the reuse of dialysers. It has been shown in few studies that there is loss of surface area of dialyser with occlusion of individual fibers by proteinaceous material which comes from patient's blood, leading to decrease in urea clearance.¹⁴ Gotch reported that a 20% reduction in total cell volume had no significant effect on clearance of small molecules. The study showed that reduction in dialyser membrane surface area is partly compensated by increased blood flow through remaining fibres.¹⁵ In the 90s, high flux dialyser became available and blood flow was increased from 200 ml/min to more than 300 ml/min. Ouesph et al in a landmark study reported that with reused high flux dialysers and flow more than 300 ml/min, a residual TCV of 80% maintained Kt/V above 1.2 i.e. dialysis adequacy is maintained till TCV fall below 80%.¹⁶ As per K-DOQI guidelines dialysers having a total cell

volume (TCV) <80% of original measured value should not be reused.¹⁷ In the present study mean TCV of dialysers never fell below 90%. Hence there was no effect on Kt/V and URR during each dialysis session.

The study observed that none of the patient had intradialytic symptoms like sweating, nausea/vomiting, chest pain, hypotension, fever and rigors during first and second dialysis session, while one patient had fever, during third dialysis session. The patient was suffering from diabetic foot and pus culture sensitivity was found to be positive for staphylococcus aureus and was treated with antibiotics and referred to surgery. Centre for disease control (CDC) has reported septicaemic deaths in patients using reused dialysers, caused by Mycobacterium chelonae, a water borne microbe.¹⁸ This microbe can survive in some of the germicides used in dialyser reprocessing but is susceptible to 4% formaldehyde solution with minimum contact of 24 hours.¹⁹ In present study 4% formaldehyde was used and strict guidelines for dialyser reprocessing were followed. The monthly cultures of treated water were found to be negative. The study observed no difference in frequency of hypotension, and nausea/vomiting, before and after reuse of dialyser. No patient had chest pain during dialysis session.

The study also observed that the cost of first use of F-6 dialyser was Rs.927 and that for reuse per session was Rs.642, thus leading to a cost saving of Rs.285 per dialysis session. Haemodialysis (HD) is the mainstay of RRT in India. A study from South India reported that out of 100 patients on haemodialysis 36% were funded by their employees or by charity programmes, 30% arranged finances for their treatment by selling property, 20% raised loans and only 4% were able to take care of their treatment costs solely by pooling of family resources. The current economics of dialysis is back breaking for the average Indian. Effective reuse of dialysers for hemoaodialysis can help in bringing down the cost of hemodialysis more so in the developing world.²⁰

CONCLUSION

The present study showed that use of same dialyser up to three times was effective and safe. Further, it was cost effective without jeopardising patient's safety. Therefore, if in Indian scenario, where cost of dialysis is most of the situations is borne by the patient, the dialyser reuse should be encouraged which is likely to go a long way in preventing patients dropout in dialysis programme. Further, studies enrolling more numbers of patients carried out in this direction would definitely help to substantiate the present observations.

REFERENCES

- 1.) B. Palmer. Management of Hypertension in Patients with Chronic Kidney Disease and Diabetes Mellitus. *Am J Kid Dis* 2008; 121: 16-22.
- 2.) Mani KM. Prevention of chronic renal failure at the community level. *Kid Int* 2003; 63: 586-9.
- 3.) Udayakumar N. Chronic kidney disease in India: From a resident physician's perspective. *Postgrad Med J* 2006; 82: 697-8.
- 4.) Mittal S, Kher V, Gulati S: Chronic renal failure in India. *Renal Fail* 1997; 19: 763-70.
- 5.) Daugirdas JT: Second generation logarithmic estimates of single pool variable volume Kt/v: an analysis of error. *J Am Soc Nephrol* 1993; 5: 1205-13.
- 6.) Pourfarzani V, Ghanbarpour F, Nemat E, Taheri S, Einollah B. Laboratory variables in hemodialysis patients in Iran. *Saudi J Kidney Dis Transplant* 2008; 19: 842-6.
- 7.) Twardowski ZJ. Dialyser reuse-part II: advantages and disadvantages. *Semin Dial* 2006; 19: 217-26.
- 8.) Owen W, Szczech L, Reddan D. Explaining counter intuitive outcomes predicted by Kt/V. *Semin In Dial* 2001; 14: 268- 70.
- 9.) Lobo V, Gang S, Shah LJ, Ganju A, Pandaya PK, Rajapurkar MM et al. Effect of hollow fiber dialysers reuse upon kt/v(urea). *Indian J Nephrol* 2001; 12:40-48.
- 10.) DN Manandhar, PK Chhetri, R Twari, S Lamichhane. Evaluation of dialysis adequacy in patients under hemodialysis and effectiveness of dialysers reuses. *Nepal Med Coll J* 2009; 11: 107-110.
- 11.) Ahmed MH, Abed J, Tarif N, Alam A, Wakeel JS, Memon N et al. Dialyser reuse impact on dialyser efficiency, patient mortality and cost effectiveness. *Saudi J Kidney Dis Transpl* 2001; 12:305-11.
- 12.) RA Sherman, RP Cody, ME Rogers, JC Solomchick. The effect of dialyser reuse on dialysis delivery. *Am J Kid Dis* 1994; 24: 924-26.
- 13.) Helen J, Petersen J. The Dialysis Prescription: Reuse. *Am J Nephrol* 1996; 16:52-9.
- 14.) Farell PC, Eschbach Jne, Vizzo JE, Flaherty JP, Dozof J, Robert V et al. Haemodialyser reuse: Estimation of area loss from clearance date. *Kidney Int.* 1947;5: 446-450.
- 15.) Gotch FA. Mass transport in reused dialysers. *Proc Clin Dial Transplant Forum* 1980; 10: 81-5.
- 16.) Ouesph R, Smith BP, Ward RA. Maintaining blood compartment volume in dialysers reprocessed with peracetic acid maintains Kt/V but not beta2 microglobulin removal. *Am J Kid Dis* 1997; 30: 501-6.
- 17.) National kidney foundation. K/DOQI clinical practice guidelines for hemodialysis adequacy up date. *Am J Kid Dis* 2006; 48: 2-90.
- 18.) Brown C. Current Opinion and Controversies of Dialyser Reuse. *Saudi J Kidney Dis Transpl* 2001; 12:352-63.
- 19.) Chudy R, Flaherty JP, Houekins SG. An outbreak of gram negative bacteremia in reprocessed dialysers. *Ann Intern Med* 1993; 199: 107-16.
- 20.) Mani MK. The management of end-stage renal disease in India. *Int J Artif Organs* 1998; 22:182-6.