The Incremental Cost of Providing Adequate Hemodialysis

Ashwini R. Sehgal, MD

The author is with the Division of Nephrology and the Center for Health Care Research and Policy, MetroHealth Medical Center, and with the Departments of Medicine, Epidemiology & Biostatistics, and Biomedical Ethics, Case Western Reserve University, Cleveland, Ohio.

Background. *One-sixth of American hemodialysis patients receive an inadequate dialysis dose (Kt/V). Kt/V may be increased by increasing the dialysis prescription or by changing from catheters to fistulas or grafts. However, the fixed reimbursement that facilities receive per treatment may act as a disincentive to providing longer treatments or using more expensive dialyzers. We sought to quantitate the incremental cost to facilities of providing adequate hemodialysis to patients currently receiving an inadequate dose—the first such study to do so.*

Methods. *From a clinical trial, we identified 78 patients who were receiving an inadequate dialysis dose and who subsequently had an increased dialysis prescription or a change from a catheter to a fistula/graft. We obtained detailed labor and supply cost data from the 21 facilities caring for these patients. For each patient, we then determined any changes in Kt/V and in facility costs.*

Results. *The incremental cost per 0.10 increase in Kt/V was $1.70 per treatment, with a range of $0.93 to $2.89 on sensitivity analysis. Because patients began the trial an average of 0.19 below their facility Kt/V goal, the incremental cost required to achieve adequate dialysis for an average patient was $3.23 per treatment, which represents about one-fourth of typical facility per-treatment profit. Most of the incremental cost resulted from increased labor costs associated with longer treatment duration.*

Conclusion. *Providing an increased hemodialysis dose has a modest adverse impact on facility profitability. Whether this acts as a barrier to adequate dialysis deserves further examination.*

Hemodialysis dose is quantified by the parameter Kt/V, a measure of urea removal during treatment. A single-pool Kt/V of 1.20 (which corresponds roughly to a 65% reduction in blood urea nitrogen levels) is considered an adequate dose. Kt/V corresponds strongly with survival and is estimated to be inadequate in one-sixth of American hemodialysis patients.[1,2] Inadequate dialysis is also associated with increased hospitalizations and high inpatient costs.[3]

Kt/V may be optimized by increasing the dialysis prescription, changing from catheters to fistulas or grafts, and improving compliance.[4] However, it is possible that Medicare's reimbursement system acts as an impediment to providing an adequate dialysis dose. Outpatient hemodialysis facilities are paid a fixed amount of about $187 per treatment and report an average profit of $13 per treatment.[5,6] These figures include separately billable drugs such as erythropoietin, which are an important source of revenue.[7]

The per-treatment reimbursement, after adjustment for inflation, has declined by more than 50% over the last 25 years. This has forced dialysis facilities to take cost-cutting steps such as employing fewer and less-skilled staff, shortening treatment times, and reusing dialyzers.[8] While the prevalence of inadequate dialysis has decreased somewhat in recent years as a result of quality improvement efforts, it remains possible that the reimbursement method acts as a disincentive to providing longer treatments or using more expensive dialyzers.[2,9,10] Previous work has shown that facility payment levels do affect adequacy-related parameters such as length of treatment.[11]

Knowing the incremental cost of providing adequate dialysis may help providers to allocate resources and help policy-makers to develop reimbursement methods that promote adequate dialysis.[12,13] We therefore sought to quantitate the incremental cost to facilities of providing adequate hemodialysis to patients currently receiving an inadequate dose. We did this by examining changes in dialysis dose and in two components of facility costs (supplies and labor) among patients in a clinical trial designed to improve hemodialysis adequacy.[4]

Because facilities don't track costs on a per-patient basis, it is difficult to determine actual changes in costs. Moreover, because the clinical trial was restricted to a few randomly selected patients at each facility, any lengthening of patient treatments could be handled by slightly increasing the responsibilities of pre-existing staff rather than by increasing staff hours or hiring additional personnel. However, additional personnel and/or staff hours may be required if all patients receiving inadequate dialysis were targeted. Thus, we chose to estimate the incremental cost of providing adequate dialysis assuming no increase in staff productivity.

METHODS

Subjects

One hundred sixty-nine patients from 31 hemodialysis facilities in northeast Ohio participated in a 6-month-long randomized, controlled trial to improve adequacy of hemodialysis.[4] Randomly selected patients were eligible for the trial if their most recent Kt/V and mean Kt/V for the prior 3 months were both less than their facility Kt/V goal. This ensured that only patients with persistently low Kt/V values were selected. Additional patient eligibility criteria were an age of 18 years or older, English speaking, mentally competent, and having been on dialysis for at least 6 months.

Intervention patients and their nephrologists received specific recommendations on how to optimize dialysis prescription, expedite conversion of catheters to fistulas or grafts, and limit shortening of treatment time.

Control patients continued to receive usual care from their nephrologists. Neither control patients nor their nephrologists received any recommendations. After 6 months, intervention patients had twofold larger increases in Kt/V compared to control patients, and were more likely to achieve their facility Kt/V goal (62% vs. 42%, $p = 0.01$).

From participants in this clinical trial, we selected intervention and control subjects who had an increased dialysis prescription or a change from a catheter to a fistula or graft. An increased dialysis prescription may result from a longer treatment duration, increased blood or dialysate flow, or a higher efficiency dialyzer.[4]

This is the first study to quantitate the incremental cost of providing adequate hemodialysis to patients currently receiving an inadequate dose.

Facility Labor and Supply Costs

The administrator of each facility was asked to report the following:

- The number (in full-time equivalents) of employed registered nurses, licensed practical nurses, and patient care technicians, including both permanent and temporary employees.
- The salary and benefits for each type of employee.
- The names and costs of all dialyzers utilized by the facility.
- The average number of reuses for each type of dialyzer.
- The supply costs associated with catheter, graft, and fistula use.
- The supply costs associated with each additional hour of treatment time.
- The number of treatment hours per week.

Statistical Analysis

We outline below our approach for calculating the incremental (or marginal) cost associated with increases in dialysis prescription or changes from a catheter to a fistula or graft. Note that we ignored facility costs that are unlikely to be associated with changes in these treatment parameters (e.g., dietitian salaries).

For each facility, we calculated total nurse/technician salary and benefits per hour of treatment time. We also calculated cost per reuse for each dialyzer and applied these figures to patients who switched dialyzers in order to estimate the supply costs of changing to a higher efficiency dialyzer. We used descriptive statistics (mean, range) to examine each component of facility labor and supply costs.

We used a standard formula to calculate single-pool Kt/V at the beginning and end of the trial.[14] We then aggregated the changes in facility costs and changes in Kt/V across all patients. In our base analysis, we calculated the ratio of changes in cost over changes in Kt/V. In sensitivity analyses, we varied cost components across the entire range of facilities. For example, we varied labor costs from those at the facility with the lowest staff salaries to those at the facility with the highest staff salaries.

Note that facilities generally schedule patients into three or four shifts per day (e.g., early morning, late morning, and midafternoon). This can make it difficult to accommodate patients with very long treatment durations. For example, lengthening a treatment to the point that it no longer fits entirely into the early-morning shift will prevent the late-morning shift from being used for another patient. At a busy facility, this could result in the loss of the profit that would have accrued from using the late-morning shift for another patient. At a less busy facility, no profit loss would occur if the late-morning shift were not full. Alternatively, a facility could place two patients with long treatments into three shifts. Thus, the profit loss associated with lengthening a treatment to the point that it no longer fits into one shift may vary from none to one treatment's profit. We used this range for our sensitivity analyses and used the midpoint (loss of one-half of a treatment's profit) for our base analysis.

In a subsidiary analysis, we addressed the fact that patients generally require one-to-one care from nurses or technicians during the beginning ("initiation") and end ("termination") of treatment. At other times ("middle of treatment"), a single staff member can be responsible for several patients because less care is required. Because lengthening treatment duration will affect the middle of the treatment but not initiation or termination time, we separated labor costs into these three components. This analysis resulted in a small (10%) decrease in our incremental cost estimate and is not presented in the results.

Table I. Subject characteristics (n = 78).

Mean age (yr)	56
Gender (%)	
male	77
female	23
Race (%)	
black	64
white	33
Hispanic	3
Cause of renal failure (%)	
diabetes	40
hypertension	33
glomerulonephritis	5
other	22
Mean dialysis duration (yr)	3.1
Baseline Kt/V (mean)	1.13
Facility Kt/V goal (% of facilities)	
1.20	23
1.30	37
1.40	40
Facility Kt/V goal minus baseline Kt/V (mean)	0.19

Table II. Costs associated with changes in dialysis prescription or vascular access (n = 21 facilities).

	Mean ($)	Range ($)
Labor Costs		
Staff salary and benefits (per additional hour of treatment time)	+11.37	+6.21 to +19.44
Supply Costs		
Change to higher efficiency dialyzer (per reuse)	-0.13	-0.49 to +0.49
Change from catheter to fistula or graft (per treatment)	-6.21	-9.96 to -2.38
Other supply costs (per additional hour of treatment time)	+1.16	+0.60 to +2.25
Lost Profits		
Treatment too long to fit into one shift (per treatment)	+6.58	0.00 to +13.16

RESULTS

Subject and Facility Characteristics

Seventy-eight patients had an increase in dialysis prescription or a change from a catheter to a fistula or graft. Fifty-three (68%) were from the intervention group, and 25 (32%) were from the control group. The mean age of the subjects was 56 years, about three-fourths were male, and about two-thirds were black (*Table I*). Subjects began the trial an average of 0.19 below their facility Kt/V goal.

Of 31 hemodialysis facilities in northeast Ohio, two declined to participate in the clinical trial, and eight participated but did not have any patients with an increase in dialysis prescription or change in vascular access. Of the 21 facilities that contributed subjects to this cost analysis, 86% were freestanding (vs. hospital-based) and 81% were for-profit.

Changes in Dialysis Prescription and Access

Among all 78 patients, the average change in Kt/V was +0.20. Fifty-nine patients had an increase in treatment time of, on average, 23.5 minutes (range = 4.8–60 minutes). Six of these patients had a new treatment time that no longer fit into a single shift. In addition, 20 patients switched to a higher efficiency dialyzer, and 10 patients switched from a catheter to a fistula or graft.

Facility Costs

Among the 21 facilities, staff salaries and benefits averaged $11.37 per hour of treatment time, with a range of $6.21 to $19.44 (*Table II*). Changing to a higher efficiency dialyzer had a minimal impact on facility supply costs. Fistula/graft use was associated with $6.21 lower supply costs than catheters. Catheter-associated supplies included drapes, concentrated heparin in each port, caps on each port, and dressing material. Other supplies such as dialysate and heparin infusion averaged $1.16 per hour of treatment time. Lost profits from lengthening a treatment to the point that it no longer fit entirely into one shift ranged from $0 (when the next shift was not full) to $13.16 (when the next shift was full).

Incremental Cost

The increase in treatment time among 59 subjects was associated with a combined increase of $263 in labor costs and $27 in supply costs (*Figure 1*). Use of fistulas/grafts was associated with a combined decrease of $62 in supply costs.

The total change in costs among all 78 patients was $265, while the total change in Kt/V was 15.6, thereby giving an incremental cost of $1.70 per 0.10 increase in Kt/V. Because patients began the trial an average of 0.19 below their facility Kt/V goal, the incremental cost required to achieve adequate dialysis for an average patient was $3.23 per treatment.

Sensitivity Analysis

By varying staff salaries and benefits from the lowest to the highest values reported by the 21 facilities (*Table II*), the incremental cost per 0.10 increase in Kt/V ranged from $0.93 to $2.89 (*Figure 2*). Varying other facility costs had a smaller impact on incremental cost.

DISCUSSION

This is the first study to quantitate the incremental cost of providing adequate hemodialysis to patients currently receiving an inadequate dose.

The incremental cost of $3.23 per treatment was largely due to increased labor costs associated with longer treatment duration. Lengthening treatments to the point that they no longer fit entirely into one slot had a much smaller impact on incremental cost, since this applied to only 6 patients in this sample. Changing from catheters to fistulas or grafts had the dual benefit of increasing Kt/V while decreasing facility costs. Changing dialyzers had little impact on supply costs because the dialyzer cost per reuse is relatively small.

Because the total incremental cost is about one-fourth of the $13 that outpatient hemodialysis facilities typically make in profit per treatment, providing an increased dialysis dose would have a modest adverse impact on facility profitability. It is worth pointing out that our incremental cost estimate of $3.23 per treatment applies only to patients receiving inadequate dialysis (or one-sixth of patients at an average facility). If this amount were distributed across all patients, the cost per treatment would decrease to $0.54.

Although our study was not designed to determine whether cost

Baseline Analysis of Incremental Cost

Increased Treatment Time	
59 patients x $11.37 labor costs/hr x 0.392 hr	= $262.97
59 patients x $1.16 supply costs/hr x 0.392 hr	= $26.83
Higher Efficiency Dialyzer	
20 patients x ($0.13 supply costs)	= ($2.60)
Change from Catheter to Fistula/Graft	
10 patients x ($6.21 supply costs)	= ($62.10)
Treatment Too Long to Fit into One Slot	
6 patients x $6.58 lost profits	= $39.48
Total Change in Costs	= $264.58
Total Change in Kt/V	
78 patients x 0.20	= +15.6
Incremental Cost per Patient per 0.10 Increase in Kt/V	
$264.58/156	= **$1.70**

Figure 1. Fifty-nine patients had an increase in treatment time of, on average, 23.5 minutes, or 0.392 hours. Among all 78 patients, the average change in Kt/V was +0.20. Values represent costs for one treatment provided to the stated number of patients. (Values in parentheses represent negative numbers.)

considerations actually act as a barrier to adequate dialysis, our findings suggest that this issue deserves further examination. In particular, it would be important to understand the relative importance of cost considerations vs. previously identified barriers such as medical limitations, patient noncompliance, and physician preferences.[4]

By engaging the participation of virtually all dialysis facilities and nephrologists in a large geographic area, we enhanced the generalizability of our findings. With the exception of sex and race (*Table I*), patient characteristics and facility characteristics were comparable to national figures.[15] As expected, males and blacks are over-represented among patients receiving inadequate hemodialysis.[16] This appears to be due to a larger body size and more frequent shortening of treatment time by males and blacks.[17-20] Our sensitivity and subsidiary analyses provide further evidence of the robustness of our findings.

Importance of the Results

Our findings have important implications for dialysis providers and health policy-makers. Dialysis providers face the challenge of allocating increased supply and staff costs while remaining financially viable. Even nonprofit facilities must make a profit in order to pay for future expansion, charity care, and unforeseen expenses. To some extent, the decrease in short-term profits associated with efforts to increase Kt/V may be offset by improved patient survival and increased long-term revenue.[12]

Health policy-makers should consider alternative reimbursement methods that promote adequate dialysis.[21-23] If providing adequate dialysis decreases hospitalization rates, then any increased funding for outpatient dialysis treatment may be offset by decreased inpatient expenditures.[24] In a previous investigation, we estimated that increasing Kt/V by 0.19 (the average amount needed to achieve an adequate Kt/V in the present sample) was independently associated with an 18% decrease in odds of hospitalization and a $3,600 decrease in annual Medicare inpatient expenditures.[3]

Study Limitations

Several limitations must be considered when interpreting our results. First, we focused on facilities in a single geographic area. Labor and supply costs may be different in other regions. In addition, a larger number of patients than encountered in this study may need an increased treatment time or a treatment that won't fit into one shift at some facilities. While we did not have data on facility occupancy rates, it is likely that full facilities will incur higher costs if a treatment won't fit into one shift compared to facilities that are not full. We also dealt with labor costs in a linear fashion, i.e., we assumed no increase in productivity. However, up to a certain point, any lengthening of patient treatments

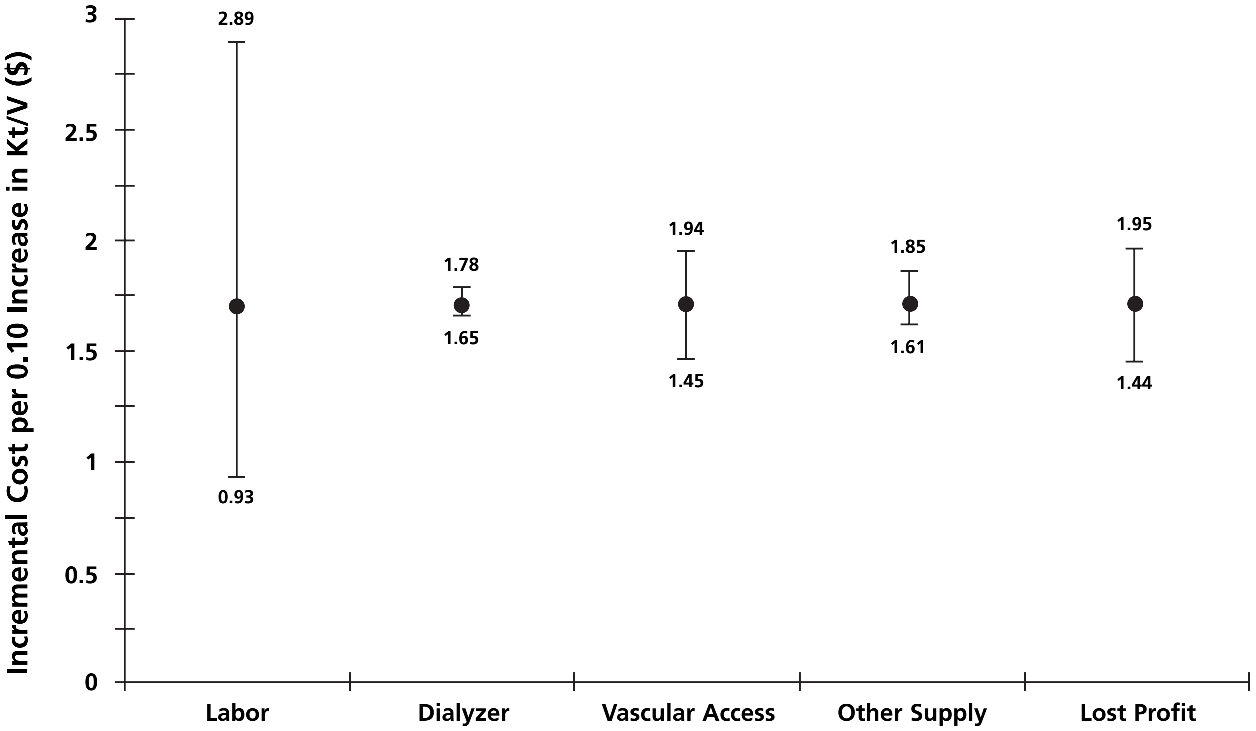

Figure 2. Sensitivity analysis of incremental cost per 0.10 increase in Kt/V. The points (solid dots) represent the base analysis, while the upper and lower bars represent the range of results across all facilities.

may be handled by slightly increasing the responsibility of pre-existing staff rather than increasing staff hours (possibly involving overtime) or hiring additional personnel.

Second, our results should not be interpreted as indicating that it is possible to purchase a Kt/V increase of 0.10 by spending $1.70. In fact, it is generally only possible to purchase an entire package of interventions (in this case, a higher prescription or better vascular access) to achieve a set of outcomes (in this case, increased Kt/V among a group of patients). Individual patients may have incremental costs that are higher or lower. For example, a large patient who needs to lengthen treatment time in order to increase Kt/V will have a higher incremental cost than would a patient who only needs a higher efficiency dialyzer.

Third, we estimated patient-specific costs from facility-specific data rather than track actual costs on a per-patient basis. Given our modest sample size, we also did not examine interactions between various cost components. For example, changing from a catheter to a fistula/graft may not only result in decreased supply costs, but also decreased labor costs, since the higher blood flow achievable with a fistula/graft may allow for decreased treatment duration.

Fourth, we ignored overhead costs (such as rent) because they are unlikely to be affected by changes in treatment parameters. We also ignored increases in prescribed blood flow because they do not incur additional costs to the facility. However, they can contribute to increased Kt/V.

Fifth, we did not include the impact of missed treatments in our analyses because it is not possible to measure Kt/V for a missed treatment. Facilities are not reimbursed for missed treatments, but still incur certain fixed costs, such as staff salaries and benefits. While improving treatment attendance may not affect Kt/V, it will increase facility reimbursement and profits.

Sixth, the results of the HEMO Study suggest that having a Kt/V goal > 1.20 (as did some of the facilities in our sample) may not be necessary.[1]

The author is grateful to the facilities that participated in this project, which was supported by grant numbers DK51472 and DK54178 from the National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, Maryland.

References

1. Eknoyan G, Beck GJ, Cheung AK, Daugirdas JT, Greene T, Kusek JW, Allon M, Bailey J, Delmez JA, Depner TA, et al. Effect of dialysis dose and membrane flux in maintenance hemodialysis. *New Engl J Med* 2002; 347:2010-2019.
2. Health Care Financing Administration. *2000 Annual Report. ESRD Clinical Performance Measures Project.* Baltimore, MD, 2000.
3. Sehgal AR, Dor A, Tsai AC. The morbidity and cost implications of inadequate hemodialysis. *Am J Kidney Dis* 2001; 37:1223-1231.
4. Sehgal AR, Leon JB, Siminoff LA, Singer ME, Bunosky LM, Cebul RD. Improving the quality of hemodialysis treatment: A community-based randomized controlled trial to overcome patient-specific barriers. *J Am Med Assoc* 2002; 287:1961-1967.
5. Medicare Payment Advisory Commission. Report to the Congress: Medicare Payment Policy (March 2001). Washington, DC.
6. Ray N. Medicare Payment Advisory Commission, Washington, DC. Personal Communication. July 2, 2001.
7. Meyer KB, Kassirer JP. Squeezing more cost and care out of dialysis: Our patients would pay the price. *Am J Med* 2002; 112:232-234.
8. Iglehart JK. The End-Stage Renal Disease Program. *New Engl J Med* 1993; 328:366-371.
9. McClellan WM, Frankenfield DL, Frederick PR, Flanders WD, Alfaro-Correa A, Rocco M, Helgerson SD. Can dialysis therapy be improved? A report from the ESRD Core Indicators Project. *Am J Kidney Dis* 1999; 34:1075-1082.
10. Rettig RA, Levinsky NG. *Kidney Failure and the Federal Government*. Washington, DC: National Academy Press, 1991.
11. Held PJ, Garcia JR, Pauly MV, Cahn MA. Price of dialysis, unit staffing, and length of dialysis treatment. *Am J Kidney Dis* 1990; 15:441-450.
12. Parker TF. Will changing the dialysis prescription have a significant impact on patient mortality and the financial status of the facility? *Contemp Dial Nephrol* 1997; 18(6):17-19.
13. Hirth R, Held P, Orzol S, Dor A. Practice patterns, case mix, Medicare payment policy, and dialysis facility costs. *Health Serv Res* 1999; 33:1567-1592.
14. Daugirdas JT. Second generation logarithmic estimates of single-pool variable volume Kt/V: An analysis of error. *J Am Soc Nephrol* 1993; 4:1205-1213.
15. U.S. Renal Data System. *USRDS 2000 Annual Data Report*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2000.
16. Frankenfield DL, Rocco MV, Frederick PR, Pugh J, McClellan WM, Owen WF. Racial/ethnic analysis of selected intermediate outcomes for hemodialysis patients: Results from the 1997 ESRD Core Indicators Project. *Am J Kidney Dis* 1999; 34:721-730.
17. Leon JB, Sehgal AR. Identifying patients at risk for hemodialysis underprescription. *Am J Nephrol* 2001; 21:200-207.
18. Lowrie EG, Chertow GM, Lew NL, Lazarus JM, Owen WF. The urea [clearance x dialysis time] product (Kt) as an outcome-based measure of hemodialysis dose. *Kidney Int* 1999; 56:729-737.
19. Owen WF, Chertow GM, Lazarus JM, Lowrie EG. Dose of hemodialysis and survival: Differences by race and sex. *J Am Med Assoc* 1998; 280:1764-1768.
20. Leggat JE, Orzol SM, Hulbert-Shearon TE, Golper TA, Jones CA, Held PJ, Port FK. Noncompliance in hemodialysis: Predictors and survival analysis. *Am J Kidney Dis* 1998; 32:139-145.
21. Chertow G. Leveling the "paying" field in end-stage renal disease. *Am J Med* 2000; 108:666-668.
22. Farley DO, Carter GM, Kallich JD, Lucas TW, Spritzer KL. Modified capitation and treatment incentives for end-stage renal disease. *Health Care Financing Rev* 1996; 17:129-142.
23. Hidai H. Need for an incentive-based reimbursement policy toward quality care for dialysis patient management. *Kidney Int* 2000; 58:363-373.
24. Hakim RM, Breyer J, Ismail N, Schulman G. Effects of dose of dialysis on morbidity and mortality. *Am J Kidney Dis* 1994; 23:661-669. D&T