Chapter IV

ESRD Treatment Modalities

Options for renal replacement therapy include the following three major categories for patients with ESRD: renal transplantation, hemodialysis, and peritoneal dialysis. More detail about these categories is described below. Over time patients may move from one treatment modality to another, for example from CAPD to transplantation and, if the transplant fails, return to dialysis. The following sections review the different treatment options briefly, discuss trends in the use of different modalities, examine demographic differences in patterns of use of the modalities and assess other details of prescription primarily for hemodialysis patients.

Modality Options for Renal Replacement Therapy

No therapy for ESRD was available until 1960, when Belding Scribner was able to apply hemodialysis for the first time for long-term maintenance of a chronic renal failure patient through creation of a new vascular access, the external arterio-venous shunt (Scribner). Before this time hemodialysis was available only for short term replacement in acute renal failure (Peters) and a rare chronic patient had a successful renal transplant if an identical twin was available (Murray). During the 1960's, the obstacles to chronic use of peritoneal dialysis were overcome by the development of the soft Tenckhoff catheter with Dacron cuffs to create a bacterial barrier (Tenckhoff). During the same decade renal transplantation became a reality through improved understanding of immunology and immunosuppressive therapies.

In 1972 Congress enacted Medicare coverage for end-stage renal disease as part of the Social Security Amendments of 1972 which became effective in July 1993 (Fox; Rettig 1982). Several legislative changes in Medicare's ESRD program have sought to encourage reduction in treatment costs through shifts in modality to home dialysis and changes in payment methods (HCFA). A recent report from the Institute of Medicine considered the possible association between reductions in the reimbursement rate for dialysis treatments (actual as well as due to inflation) and reduced quality of care (Rettig, 1991). Some additions to coverage have also been made, notably for up to three years of immunosuppressive drugs after transplantation and for erythropoietin therapy to treat anemia in dialysis patients.

Today, over 200,000 ESRD patients are alive in the United States as a result of ESRD therapy, compared to an estimated 11,000 patients in 1973 (Evans, 1981). Opinions differ about ESRD patients' quality of life, but they themselves report general satisfaction (Evans, 1985).

Renal transplantation: Renal transplantation also became a clinical reality during the 1960s (Hamilton). Surgical technique had been well developed by the time immunological advances made transplantation a clinical reality (Murray); drug therapy was developed later which modified the immune response to allow transplantation from non-identical donors. Tissue typing came into routine use during the 1960s as did the direct cross-match between donor cells and recipient serum. More recently, improved immunosuppression with cyclosporine has further expanded treatment prospects and graft survival (Merion; Kahan). Despite these developments, transplantation in the United States has shown only a minor growth since 1986 due to limited availability of donor organs (Prottas).

There are two types of donors: living donors and cadaveric donors. Living donors are almost always blood relatives, although there has been a slight increase in recent years in living unrelated transplants. A cadaver donor is a person who is brain dead, such as an accident victim, and whose circulation and respiration are maintained until organ removal ("harvesting"). Transplantation from a cadaver donor usually requires a prolonged waiting time, averaging close to two years, whereas transplantation from a living donor can be scheduled in advance and is more likely to be done as an initial or early therapy. Survival of the transplanted kidney (graft or allograft) is influenced by a variety of factors (Opelz; Held 1994; Braun) such as HLA matching, duration of organ preservation (warm and cold ischemia time) following harvesting of the organ, presence or absence of panel reactive antibodies, patient demographic factors, and rejection episodes as well as immunosuppressive drug regimens. These factors are described further in Chapter VIII.

Hemodialysis: Removal of toxins and excess fluid is accomplished via extracorporeal circulation of blood through a dialyzer (artificial kidney). Treatments are most commonly scheduled for three to four hours, three times weekly. A vascular access, via an arterio-venous fistula, vascular graft, or indwelling vascular catheter, is required. The treatment is performed predominantly in a hospital-based or freestanding dialysis unit as "center hemodialysis". In this setting dialyzers are commonly reprocessed for multiple use.

Hemodialysis may be performed at home as "home hemodialysis" after the patient and an assistant (often the spouse) undergo several weeks of training. Home hemodialysis encourages patient independence, allows freedom to schedule dialysis to meet patient convenience, and is associated with the best quality of life among dialysis therapies (Evans).

Peritoneal dialysis (PD): An alternative dialytic therapy is available with PD, which requires placement of a catheter into the abdominal cavity and repeated instillation and drainage of sterile dialysate. Equilibration of dialysate with plasma occurs during several hours of dwell time. When the equilibrated dialysate is drained, toxins are removed through (partially) equilibrated dialysate. Osmotic ultrafiltration of fluid is achieved by use of hypertonic dialysate solutions. Several peritoneal dialysis options are available. Intermittent PD (IPD) with frequent exchanges of dialysate, usually in thrice-weekly sessions lasting 10 to 12 hours is now rarely used. During the 1980s, most IPD was replaced by continuous ambulatory PD (CAPD) as the major PD modality. For CAPD, the patient usually performs four exchanges of 2 - 3 liters dialysate with prolonged dwell times on a daily basis. Continuous cycling PD (CCPD) is also predominantly a home treatment and utilizes several exchanges through a programmed machine (cycler) every night, with one long dwell time throughout the day. The utilization of CCPD has increased in recent years, but CCPD use accounts for only one tenth of PD use. Several other variations of home PD have been described (Twardowski) but are not uniformly reported and thus are not discussed further in this report. Home PD is used frequently for patients who prefer the independence of self-care and for those who have difficulty with vascular access or other aspects of hemodialysis. Thus, there may be a selection into PD therapy for two extreme patients groups, those who are stable and independent and those who are unstable and poorly tolerant of hemodialysis (USRDS, 1992). The fraction of CAPD patients that switches to hemodialysis during the first few years of treatment is much larger than the fraction of hemodialysis patients switching to CAPD (USRDS, 1991). One may speculate that a low delivered dose of CAPD may be responsible for some switching to hemodialysis once residual renal function is lost.

Data for Modality Analyses

A complex analytical process examines a variety of data sources to determine longitudinally the treatment modalities for individual patients in the USRDS database. Additional sources are used including reports from the facility surveys of the ESRD Networks and HCFA billing summaries. The actual process is described in greater detail in Chapter XV (Technical Notes). For many cases, treatment modality and dates of change in modality must be inferred indirectly from sources such as the Medicare billing files. Because the USRDS is continually refining this process, slight variations between the modality data reported in different annual data reports should be expected.

Year End Modality Use

The treatment modality in use for all ESRD patients on December 31 is obtained from two sources: 1) the USRDS longitudinal patient treatment files ("data base") and 2) the HCFA-mandated year-end facility surveys. While both report the year-end point prevalence, the latter counts are slightly higher because they include not only Medicare but also non-Medicare patients. Figure IV-1 shows these counts for ten years, 1984 to 1993. Database numbers for 1993 likely represent a low estimate because of somewhat incomplete data. The general under count in the USRDS database is in the 6 to 7 percent range

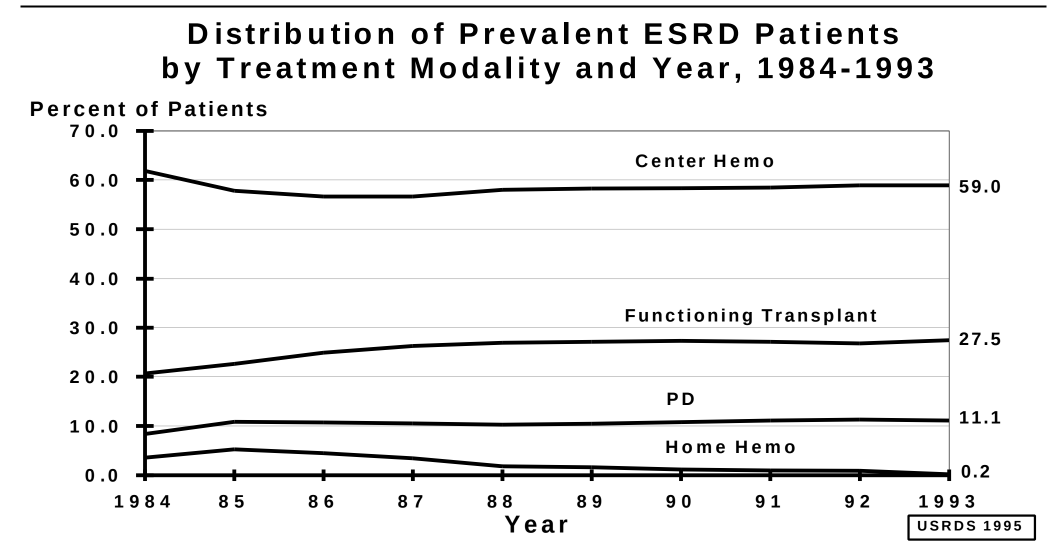

Figure IV-2

Percent distribution of ESRD patients alive on Dec. 31, by treatment modality and year, 1984-1993. Other/unknown not shown. Percentages include Puerto Rico and U.S. Territories. USRDS includes Medicare patients only. 1993 Data are preliminary. Sources *C.1,I.11*

which corresponds with the observation that about 93 percent of all ESRD patients are insured by Medicare and can therefore be expected to be counted by the USRDS.

There has been a steady increase in the overall number of patients treated, and in the number of patients on each modality. The only exception is the small home hemodialysis group, which showed a decrease in recent years. Throughout the period, patients treated with center hemodialysis constituted the largest group; patients with a functioning renal transplant were the second largest group with nearly 60,000 patients. Transplant recipients who lost their transplant function and returned to dialysis are shown in the appropriate dialysis group in these year-end prevalence counts.

CAPD/CCPD combined has been the third most common form of ESRD therapy. During the early 1980s, the use of CAPD and CCPD showed a relatively steep increase (see earlier USRDS reports). On a percent growth basis, each of the three major groups showed nearly the same rate of increase.

Figure IV-2 shows the same data as a percent distribution of patients by modality for each year. This figure clearly demonstrates that the fraction of patients with a functioning renal transplant increased until 1988. This was due to both a rise in the number of transplants performed and improvements in graft survival (see Chapter VIII). However, the relatively constant percentage since 1988 is a reflection of the scarcity of available organ donors. The fraction of patients treated with CAPD/CCPD has been fairly constant since the mid 1980s. At the end of 1993, peritoneal dialysis patients accounted for 11 percent of all ESRD patients and 15.8 percent of all dialysis patients. Before the mid 1980s, center hemodialysis had decreased relative to other modalities (Figure IV-2 and earlier USRDS reports), yet its total numbers showed a steady increase (Figure IV-1). Since 1988, the percent distribution for all modalities has essentially stabilized. Only the small fraction of patients utilizing home hemodialysis has shown a gradual decline since 1985.

There were two to three percent of patients for whom the modality could not be determined from available data (not included in Figure IV-2). This group includes "other/unknown" and unstable dialysis. Additionally, patients who initiated dialysis therapy during the last two months of the most recent year, 1993, are automatically placed in this category according to definitions outlined in Chapter XIV. Thus all prevalent patients are accounted for in this analysis.

The distribution of patients on various forms of peritoneal dialysis is shown in Figure IV-3. The use of CCPD has been increasing during the second half of the 1980s, and more steeply during the early 1990s. As of 1993, CCPD accounted for approximately 2.4 percent of all dialysis and 15.8 percent of the combined peritoneal dialysis category. This fraction reflects a clear increase in recent years. Intermittent peritoneal dialysis, usually performed in a dialysis center, is less commonly used. Patients treated with this modality and patients with unknown and other or uncertain dialysis accounted for only 0.6 percent of all dialysis patients at the end of 1993. The fraction treated by CAPD remained fairly constant since 1990.

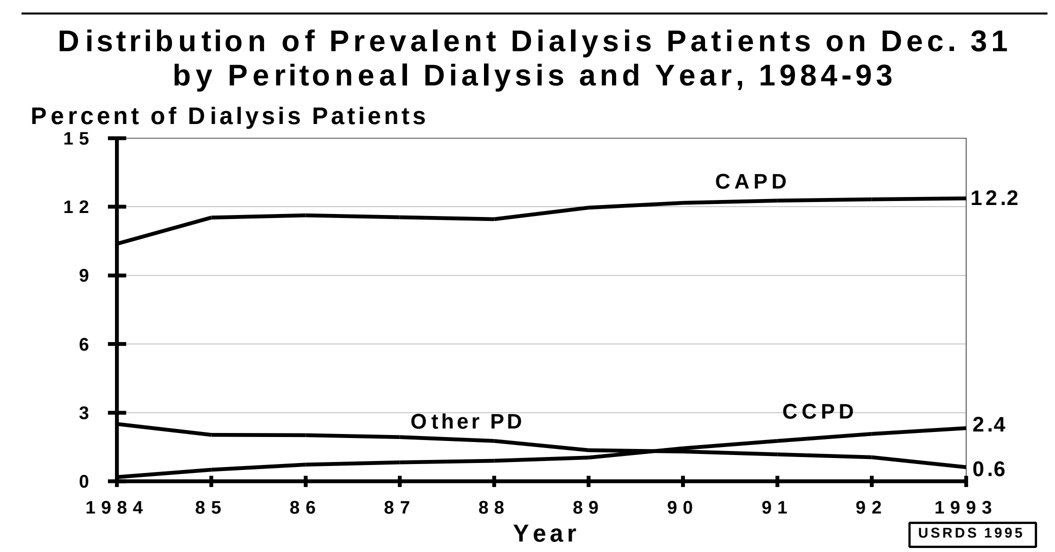

Figure IV-3

Percent distribution of Prevalent ESRD patients on December 31, by type of Peritoneal Dialysis and year, 1984-1993. 1993 data are preliminary. Percentages include Puerto Rico and U.S. Territories. Medicare patients only. Source *C.1*

Kidney Transplants by Donor Type and Patients Awaiting a Transplant By Year, 1983-93

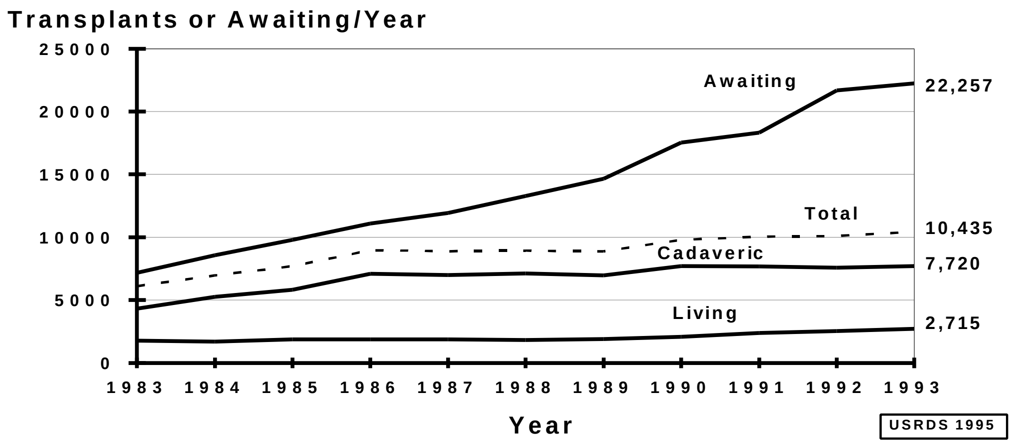

Figure IV-4

Counts of kidney transplants performed by (Medicare and Non-Medicare) patients donor type and counts of patients awaiting cadaveric transplant by year, 1983-1993. Source: I.10

						...lysis Patients On ...ne ...no	CAPD	CCPD
N							14.2	2.5
N							13.2	1.3
N							13.3	2.4
N							11.0	1.3
N							9.6	0.8
N							10.6	3.2
N							8.7	2.2
N							10.8	1.6
No. 9 (IN, KY, OH)	14,599	43.3	25.9	55.8	76.6	1.2	17.5	1.0
No. 10 (IL)	8,768	36.7	33.7	55.8	83.6	0.7	9.5	1.1
No. 11 (MI, MN, ND, SD, WI)	14,002	47.0	20.4	55.3	73.4	1.7	18.0	1.3
No. 12 (IA, KS, MO, NE)	7,036	43.1	19.5	57.0	72.2	2.6	19.8	2.3
No. 13 (AR, LA, OK)	7,171	29.0	42.7	56.3	84.6	1.1	11.3	1.8
No. 14 (TX)	13,729	30.2	28.1	55.8	86.7	1.1	8.5	1.8
No.. 15 (AZ, CO, NM, NV, UT, WY)	7,210	36.8	6.7	55.4	80.0	1.9	11.9	2.8
No. 16 (AK, ID, MT, OR, WA)	4,908	43.5	5.6	53.4	70.6	10.0	14.6	1.9
No. 17 (AS, N-CA, HI, CM, GU)	9,288	36.3	15.2	57.2	85.2	0.6	10.6	1.4
No. 18 (S-CA)	13,176	35.2	17.5	57.6	87.5	0.2	8.9	1.5
TOTAL	191,551	34.5	30.0	55.8	81.3	1.4	12.1	1.8

Source: Reference Table C.17, special analysis

Table IV-1

To assess regional differences in the utilization of various treatment modalities, the percent of patients by modality an d 18 geographic regions of the 18 ERSD Networks is provided for all ESRD patients alive at the end of 1992 in Table IV-1. Compared to the national summary data (totals), this table shows large variations for certain regions. The median age varied by region from 53.4 to 60.2 for an average of 55.8 years. For the assessment of the percent of patients with a functioning transplant those patients aged 65 years or older were excluded. The percent of ESRD patients with functioning transplant had a two fold range (from 24 to 47 percent) with an average of 34.5. Regions with a relatively high percentage of black patients tended to have low fractions with transplants, although this is not the sole explanation. The fraction with CAPD ranged from 8.5 to 19.8 for an average of 12.1 percent of all ESRD. The relatively high percentages observed in Midwestern states may be related, in part, to the distances of patients from the nearest dialysis facility as analyzed in the USRDS 1991 Annual Data Report. CCPD was used in 1.8 percent of dialysis patients and also had a wide range of utilization (0.8 to 3.2 percent). The utilization of CCPD did not appear to correlate with that of CAPD. Home hemodialysis was used overall in 1.4 percent of ESRD patients with one region showing numbers as high as 10 percent.

Although it is difficult to fully explain the observed regional differences, it is important to describe them to allow local efforts to be directed towards improved patient access to all modality options.

The activity in renal transplantation by year is shown as the numbers of living related and cadaveric renal transplants performed per year for 1983-93 in Figure IV-4. These data are based on the Annual Facility Survey completed by all providers at the end of each year (see Chapter XI). The number of cadaveric transplants performed per year increased steeply before 1986. However, there was only a minute increase between 1986 and 1993. The relatively stable number of cadaveric transplants performed in recent years is in sharp contrast with the steeply increasing number of patients on the waiting list for cadaveric transplants. This widening gap between supply and demand for cadaveric kidneys from 1986 through 1993 (Figure IV-4) has serious implications, since it causes the waiting period for ESRD patients desiring a cadaveric transplant to increase even further. Thus, there is a clear need for increased organ donation in the U.S.

The number of living donor transplants has increased only slightly during 1983 to 1993. There appears to be a somewhat greater increase since 1989 which may be in response to the limited supply of cadaveric organs. An increase in living donor transplantation would appear desirable given its superior patient and graft survival figures (Chapter VIII). More details about the transplant process and the demographics of transplant donors and recipients is provided in Chapter VIII.

Utilization of Modalities by Patient Characteristics

Wide variations in the utilization of the various treatment modalities existed by patient characteristics in 1992. The demographics of access to transplantation has been well-studied (Gaylin; Webb) and is discussed further in chapter VIII. For pediatric age groups, a detailed discussion of treatment modalities is provided in Chapter IX.

Table IV-2 describes the modality use by age, sex, race and cause of ESRD. Overall center hemodialysis was the most common form of ESRD therapy (59.2 percent) among prevalent patients at the end of 1992. Functioning renal transplant accounted for 26.8 percent, CAPD/CCPD for 10.5 percent and home hemodialysis for 0.9 percent of all ESRD patients treated at the end of 1991. Only 2.6 percent of prevalent patients were treated by other forms of PD or by uncertain or unknown dialysis.

By age group, younger patients had a much higher fraction of functioning transplants than older patients. Compared to 61.9 percent of ESRD patients with functioning transplants in the under 20 age group, there were 27.4 percent in the 45-64 age group and only to 4.5 percent in the 65 year and older group. The percentage using CAPD/CCPD appeared relatively stable across age groups ranging from 10.2 to 14.4 percent. Hemodialysis was used infrequently in the pediatric ages accounting for 17.2 percent for in center and home hemodialysis combined. By contrast, the oldest age group (>65 years) was primarily treated by center hemodialysis, 82.9 percent. Home hemodialysis did not show much variation by age, except that children were underrepresented.

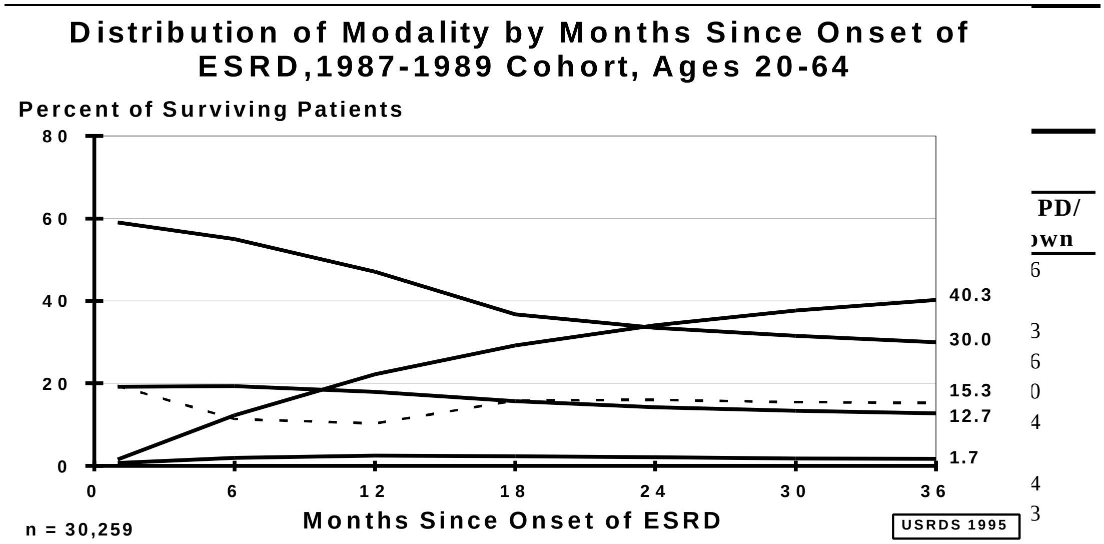

Figure IV-5

Percent distribution of patients by treatment modality by months since start of ESRD treatment for all patients starting treatment in 1987-1989. Medicare patients only. Source: Special Analysis

Native American	22.5	61.5	3.4	11.2	1.2
Asian/Pacific Islander	27.7	60.6	0.5	9.3	1.7
Black	13.7	75.2	0.5	8.1	2.1
White	33.1	51.5	1.0	11.7	2.4
Diabetes	18.1	67.4	0.7	11.9	1.7
Hypertension	13.0	74.5	0.7	10.1	1.4
Glomerulonephritis	41.4	44.8	1.1	10.9	1.5
Cystic Kidney Disease	41.7	44.0	1.5	10.8	1.7
All Other	35.8	49.2	1.2	9.0	4.7

** Percentages add across to ~ 100*

Source: Reference Tables C7,C11

Table IV-2

Racial differences in modality usage are apparent in this table. In the categories of functioning transplant, whites were over-represented and blacks underrepresented by a wide margin when compared to the average of 26.8 percent. The differences for the fractions with functioning transplants are likely due to differences both in transplantation rates (Gaylin) and in transplant graft and patient survival. Both issues are discussed in more detail in Chapter VIII.

The use of CAPD/CCPD as presented needs to be interpreted with caution because of the differences in transplantation percentages. When re-analyzed as the percentage of only dialysis patients (i.e. by excluding the transplant percentages from the denominator), CAPD/CCPD accounted for 13.1 percent of dialysis, where as all PD made up for 17.8 percent of all dialysis, when other PD/ unknown modality was counted as PD. CAPD/CCPD as a fraction of all dialysis was a relatively low percentage for blacks (9.4 percent) and for Asian Americans (12.9 percent), whereas the corresponding percentages were comparatively high for Native Americans (14.5 percent) and whites (17.4 percent).

Home hemodialysis was used by 1.2 percent of dialysis patients overall. Among Native Americans home hemodialysis accounted for a much higher fraction of 4.4 percent of dialysis patients compared to 1.5 percent for whites and 0.7 percent for blacks and Asian Americans. These observations could possibly be explained in part by differences in driving distances to dialysis facilities.

Males had a higher percentage of functioning transplants (29.7 percent) compared to females (23.1 percent) which agrees with the finding of greater transplantation rates for males (Gaylin; Webb). Males and females utilized CAPD/CCPD at a nearly equal percentages of all dialysis patients (14.5 and 14.1, respectively).

Table IV-2 also shows treatment modality use for prevalent patients by major cause of ESRD. The fraction of patients with a functioning transplant was

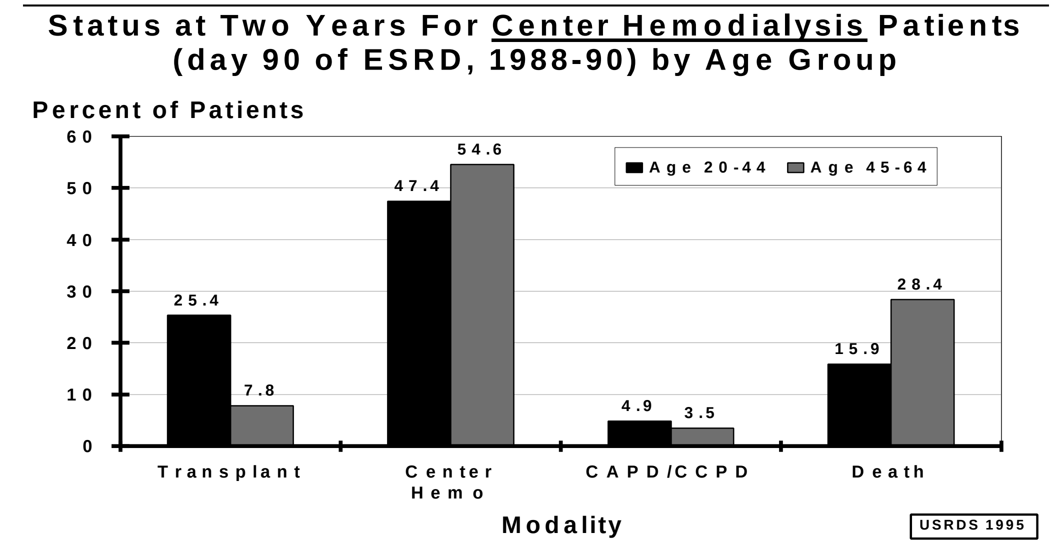

Figure IV-6

Status at Two Years for Patients Receiving Center Hemodialysis at Day 90 during 1988-90, by Age Group. Uncommon modalities are not shown. Medicare patients only. Source C.19

much higher for patients with glomerulonephritis and cystic kidney disease (41 - 42 percent). By contrast, prevalent patients with diabetes or hypertension as cause of ESRD had only 18 and 13 percent with functioning transplant. The use of CAPD/CCPD appears to be similar by diagnosis group in this table. However when re-analyzed as a fraction of only dialysis patients, it was relatively high in the glomerulonephritis and cystic disease groups (18.6 percent) and relatively low in the hypertension group (11.6 percent). Among dialysis patients, home hemodialysis was used more than twice as much in the glomerulonephritis and cystic disease groups (1.9 - 2.6 percent) compared to the diabetes and hypertension groups (0.9 - 0.8 percent). The use of home hemodialysis was overall less than one tenth of the CAPD/CCPD use in 1992.

Sequential Modality Uses

After the start of ESRD therapy many patients change modalities over time. The pattern of these changes in modality can be very simple, such as hemodialysis followed by transplantation, or it can be very complex, with multiple switches among dialysis modalities and multiple transplants with periods of dialysis following graft failure. This report examines the modality histories of a cohort of patients who started ESRD therapy during the years 1986 and 1987 and follows individual patients during their first three years of treatment.

This method describes the distribution of treatment modality by month since start of therapy among survivors of this cohort of patients. Although the modality is determined for each patient at the end of each month after the patient's first month following onset of ESRD, Figure IV-5 shows distributions only at three month intervals. Ages 20 - 64 years at start of ESRD were chosen for presentation because it shows transplantation, which would be negligible for older age groups. The ordinate represents percent of living patients, and the abscissa represents months since onset of ESRD.

Figure IV-5 illustrates that the fraction of incident patients with functioning renal transplant increases gradually over time. Center hemodialysis is the dominant dialytic modality throughout. During the first 10 months, the peritoneal dialysis group is larger than the transplant group but subsequently is exceeded by functioning transplants. The use of peritoneal dialysis and home hemodialysis show slight declines over the first three years of ESRD.

Compared to the number of patients with a functioning transplant at 3 years, about one third had a functioning transplant by their sixth month and over one half by their twelfth month. All other modality groups showed a gradual decline, which was in large part due to the increasing fraction with a functioning transplant.

Similar data have been presented in a stacked time-series plot by the USRDS (USRDS, 1991) and the European Dialysis and Transplant Association Registry “Selwood analysis” (Kramer) as a standard modality graph to depict the dynamics of change over time as well as the distribution at each point in time following the start of ESRD.

According to a previous study (Wolfe 1990), most changes in dialytic modality occur before the third month. Under the assumption that the modality use at 90 days into ESRD reflects the “modality of choice” their subsequent modality distribution (including death) was analyzed for the time point two years later. Figure IV-6 shows for center hemodialysis patients, defined by their treatment on day 90 of ESRD, that nearly 40 percent were still treated with the original modality. The fraction treated by CAPD/CCPD was very small (less than 5 percent of the total). The fraction with functioning transplant at two years was 25 percent for those aged 20 - 44 compared to 7.8 percent for those aged 45 - 64 years. The fraction dead was expectedly higher for the older age group.

For patients treated with CAPD/CCPD on day 90 of ESRD the subsequent treatment at two years is shown in Figure IV-7. The original modality was used in 36 to 40 percent of patients. Compared to Figure IV-6 this is a markedly lower fraction on the original therapy than for the hemodialysis group (nearly 50 percent). The fraction with functioning transplant was slightly higher (by 1.4 to 2.7 percentage points) than for the hemodialysis group. The age group 20 - 44 years had virtually the same death fraction at two years for hemodialysis as for peritoneal dialysis patients , whereas the 45 - 64 year age group showed a slightly higher fraction dead by two years for the CAPD/CCPD group. This analysis included all deaths independent of changes in modality.

The fraction of patients having switched to center hemodialysis was near 15 percent for both age groups. This fraction having switched to the main alternative dialytic modality was more than 3 fold higher for CAPD/CCPD than for hemodialysis patients (14.8 versus 4.9 percent for ages 20 - 44 and 15.5 versus 3.5 percent for ages 45 - 64 years). The question whether this discrepancy relates in part to the low dose of CAPD deserves further study, particularly as it relates to the gradual decline in residual renal function.

Prescriptions for Hemodialysis

The USRDS Case Mix Adequacy Study collected information for a random sample of 7,096 hemodialysis patients alive on January 1, 1991. Of these patients 1,729 were incident patients starting ESRD therapy during 1990. Analyses of these data are provided here regarding the average prescription of hemodialysis in the U.S. excluding the small fraction of patients treated with twice weekly dialysis or with acetate dialysate. The following analyses are based on the 4,154 patients who had been on dialysis

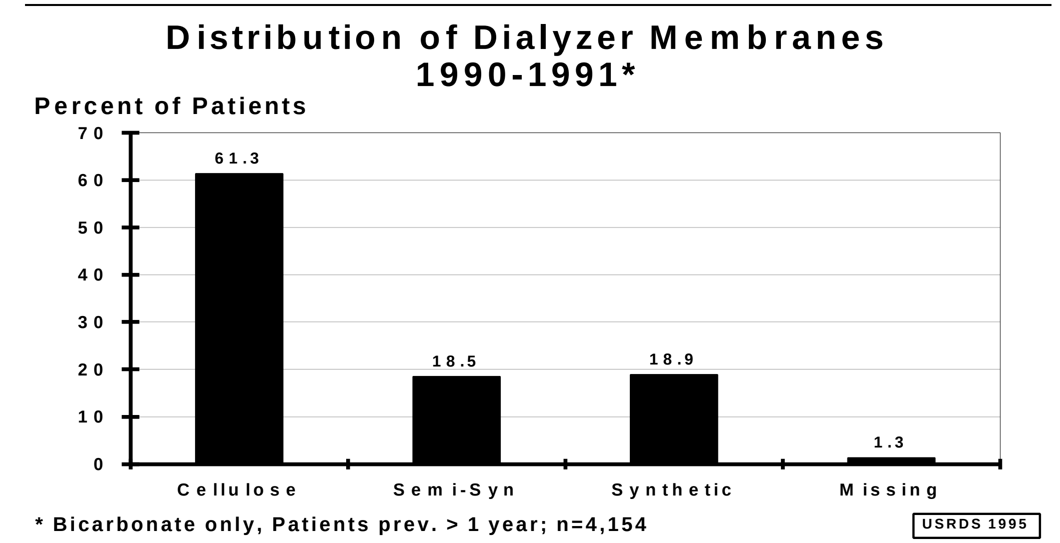

Figure IV-8

Distribution of Dialyzer Membranes, Center HD patients only, 1990-91 From the USRDS Case Mix Adequacy Study.

Figure IV-7

Status at Two Years for Patients Receiving CAPD/CCPD at Day 90 during 1988-90, by Age Group. Uncommon modalities are not shown. Medicare patients only. Source C.19

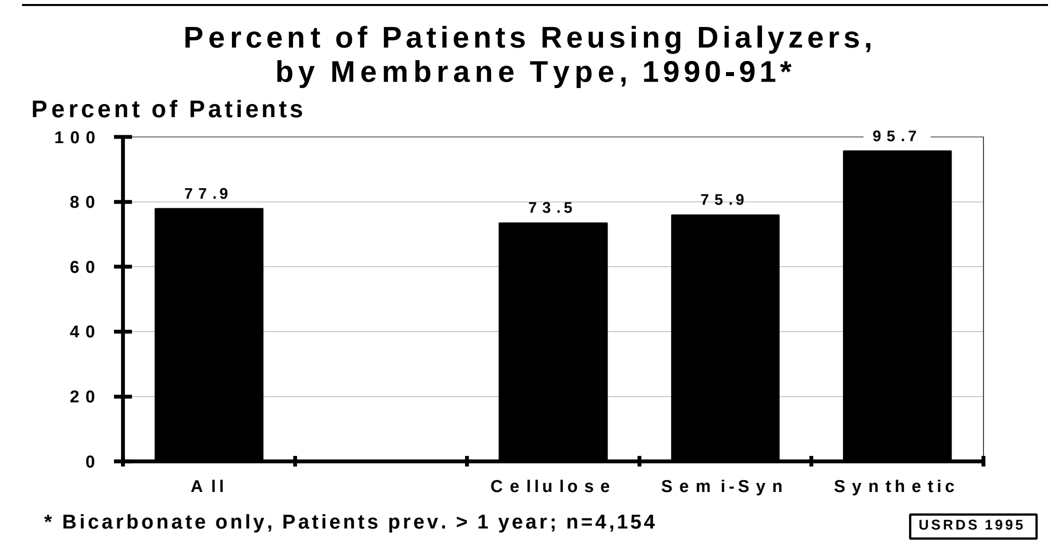

Figure IV-9

Percent of Patients Reusing Dialyzers, Center HD patients only, 1990-91. From the USRDS Case Mix Adequacy Study.

for at least one year. This selection was done to minimize the role of residual renal function on dialysis prescription under the assumption that after more than one year of dialysis residual renal function is negligible. In this case the dose of dialysis (K_d t/V) reflects the total Kt/V.

The dialyzers in use can be classified as cellulosic, semi-synthetic and synthetic. In early 1991 the most commonly used dialyzer membrane was cellulosic, accounting for 61 percent. As shown in Figure IV-8, semi-synthetic and synthetic membranes made up the remainder at 19 percent each.

The reuse of dialyzers varied by membrane type as shown in Figure IV-9. Ninety-six percent of synthetic membranes were reused, compared to 73.5 percent for cellulosic membranes. The overall rate of reuse was 77.9 percent. It is of interest that the more expensive dialyzers appear to be more commonly

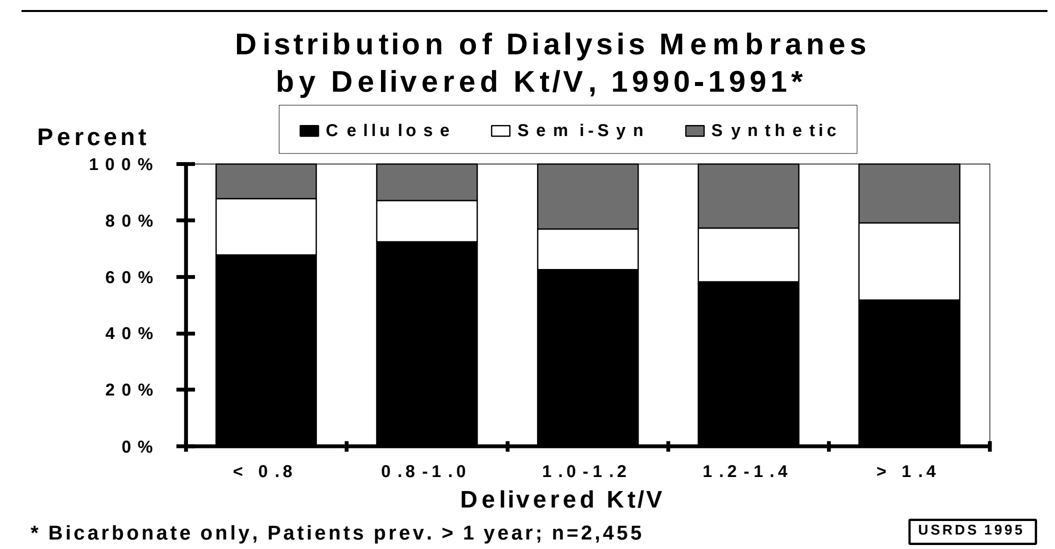

Figure IV-10

Distribution of Dialyzer Membranes by delivered Kt/V, Center HD patients only, 1990-91. Medicare Patients only. From the USRDS Case Mix Adequacy Study.

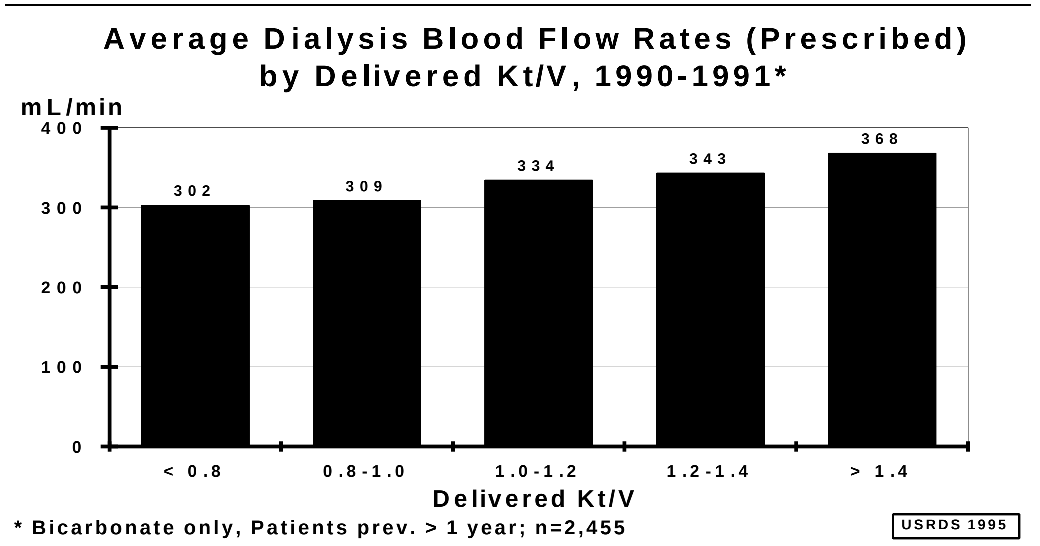

Figure IV-11

Average Dialysis Blood Flow Rates by delivered Kt/V, Center HD patients only, 1990-91. Medicare Patients only. From the USRDS Case Mix Adequacy Study.

reused.

The USRDS has reported a correlation of dialysis dose with mortality risk in that patients treated with a 0.1 higher Kt/V had a 7 percent lower mortality risk and those treated with a 0.2 higher Kt/V had a 14 percent lower mortality risk (Port). The following analyses are based on the same sample of 2455 prevalent patients (ESRD > 1 year) for whom a delivered Kt/V could be estimated near January 1, 1991 according to treatment times, and pre and post dialysis BUN and weights (Daugirdas). Figure IV-10 shows the percent utilization of dialyzer membrane categories by groupings of delivered Kt/V. It demonstrates that the fraction using cellulosic membranes decreased with higher Kt/V for ranges above 0.8.

Other components of the dialysis prescription also appear to follow the expected trends. As shown in

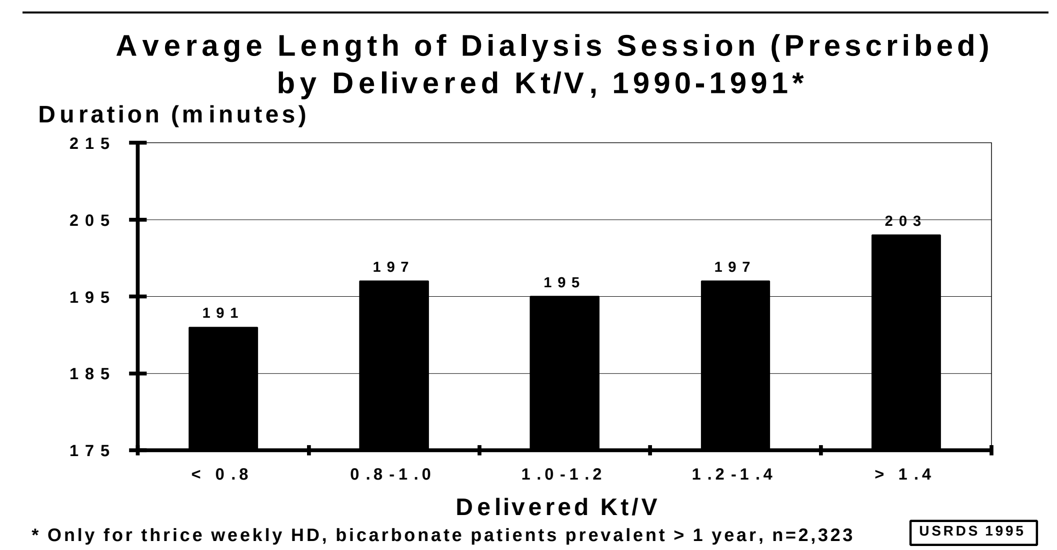

Figure IV-12

Average Length of Dialysis Session by delivered Kt/V, Center HD patients only, 1990-91. Medicare Patients only. From the USRDS Case Mix Adequacy Study.

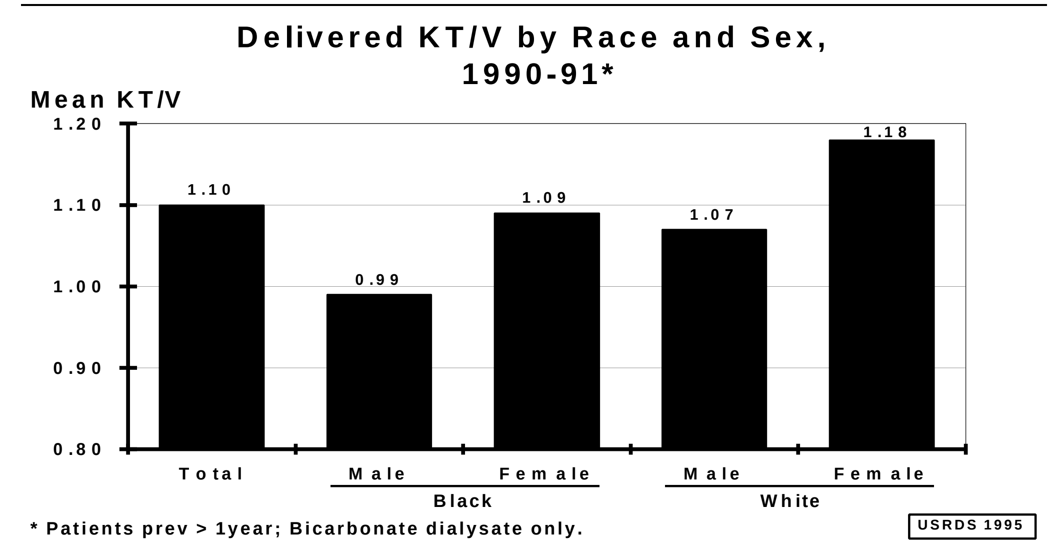

Figure IV-13

Average Length of Dialysis Session by delivered Kt/V, Center HD patients only, 1990-91. Medicare Patients only. From the USRDS Case Mix Adequacy Study.

Figure IV-11, higher dialysis blood flow rates were prescribed for patients receiving higher doses of dialysis. The duration of dialysis per thrice weekly session was also longer for patients receiving a higher Kt/V as demonstrated in Figure IV-12

Differences in the delivered dose of dialysis are observed by race and sex as shown in Figure IV-13. Black male and female patients received a lower Kt/V than their white counterparts. Additionally, this figure shows that black and white women received a larger dose than corresponding men. These findings would be explained in part, if the dialysis dose was prescribed independent of weight, in which case patients with relatively low body weight receive a relatively high dose of dialysis.

The average components of hemodialysis prescription are shown in Table IV-3 including median values and high and low percentiles. It demonstrates that in January 1991 a quarter of patients received a Kt/V of 0.93 or less, which is far below the level recommended by the re-analysis by Gotch and Sargent of data from the National Cooperative Dialysis Study (Gotch). It is also lower than the more recent recommendations of the NIH Consensus Conference (1994). The median delivered Kt/V was 1.09 which was achieved with a median prescribed blood flow of 300 (mean 330) ml/min, a dialyzer surface area of 1.2 m^2 and a duration of

Distribution of Hemodialysis Treatment Parameters 1990-91[1]

Parameter[2]	N	Mean	min	25%	50%	75%	max
Blood Flow Rate	2450	330	150	300	300	400	550
Dialysis Minutes[3]	2323	197	100	180	180	225	300
Surface Area (Dialyzer)	2431	1.32	0.40	1.00	1.20	1.80	2.20
Delivered Kt/V	2455	1.10	0.41	0.93	1.09	1.26	1.96

[1] USRDS Case Mix Adequacy Study, Bicarb patients prev > 1 yr.
[2] All parameters except delivered Kt/V are as prescribed.
[3] Dilaysis minutes excludes twice weekly HD

Table IV-3

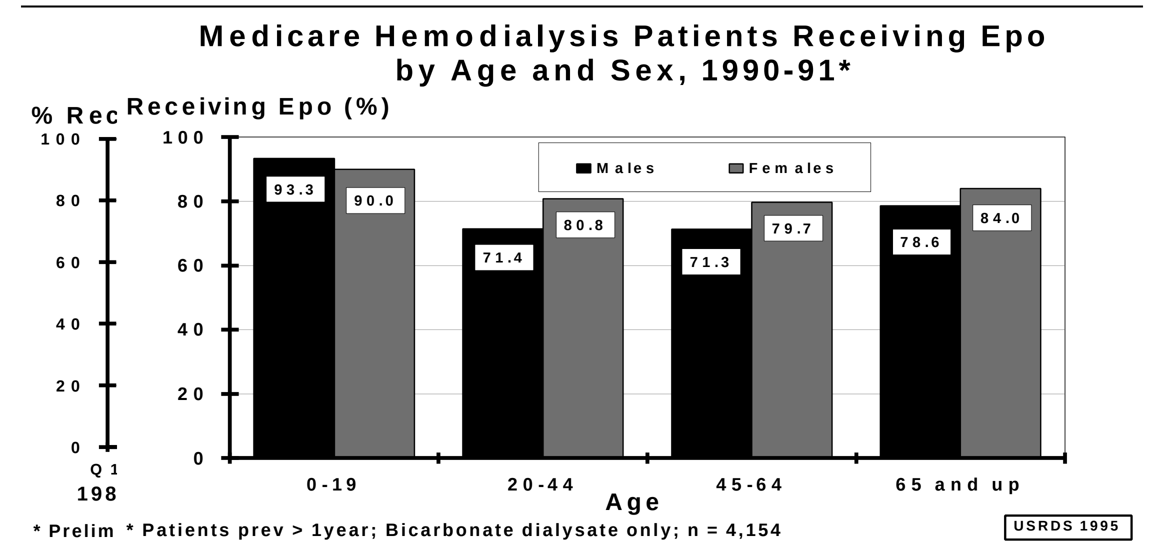

Figure IV-14 / Figure IV-15

Percent of Medicare Dialysis Patients Receiving EPO, outpatients by quarter, 1989-93. From the Quarterly Facility Report data from outpatient institutions only. (See Technical Notes, Chapter XV for details).

Patients Receiving EPO by Age and Sex, Case Mix Hemodialysis Patients only, 1990-91. Data from USRDS Case Mix Adequacy Study

dialysis of 3 hours. More than half of the patients dialyzed for 3 to 3.5 hours (mean = 195 min) on the thrice weekly schedule with the extremes being 1.5 and 6 hours.

The issues of hemodialysis dose and "adequacy" have been discussed elsewhere in more detail (Hakim). An earlier study has shown a correlation of dialysis duration (hours) with mortality risk (Held), which deserves further investigation to ascertain whether time plays a role independent of Kt/V.

Dialysis Prescription for CAPD

Since the recent Case Mix Adequacy sample did not include CAPD patients, the prescribed dose of CAPD was available to the USRDS only from the incident patient sample of the 1986-87 Case Mix Severity Study. In that sample of approximately 634 patients, 68 percent of patients had a prescription of 55 to 60 liters per week (mostly four 2-liter exchanges per day). Only 4 percent of patients used larger weekly volumes. A lower weekly dialysate volume was prescribed in 27 percent of patients (USRDS 1992). These data suggest that a low dose of CAPD is prescribed to a large fraction of patients at the start of ESRD. Unless the prescription was subsequently increased when residual renal function declined, this would be an inadequate dose for a large fraction of patients. Nolph and coworkers (1994) have pointed out that a dose of 56 liters per week is inadequate for functionally anephric patients weighing more than 65 kg. No national data are presently available on the actually delivered volumes of dialysate in CAPD patients. There is also concern that depending on patient compliance a lower than prescribed dose may be delivered. These issues may explain in part the outcomes for CAPD compared to hemodialysis patients (Chapters VI and VII).

Erythropoietin Use in Dialysis Patients

The utilization of recombinant human erythropoietin (EPO) has markedly increased since its introduction in the U.S. and coverage by Medicare in July 1989. As shown in Figure IV-14, the fraction of outpatients receiving EPO increased most dramatically during the first year (1989/90) for those covered by Medicare and treated with either hemodialysis and peritoneal dialysis. This fraction reached 90.2 percent by the end of 1993 (preliminary) for hemodialysis patients and remained consistently lower in peritoneal dialysis patients, reaching 56.9 percent by late 1993.

Data from the USRDS Case Mix Adequacy Study allow an assessment of patients receiving EPO and those not receiving EPO. Female hemodialysis patients were more likely to be treated with EPO than males except for ages less than 20 years as shown in Figure IV-15. This difference by sex is also present for ages over 65 years. For children and for ages over 65 years EPO is used for a higher fraction of patients than for other adult age groups. Similar issues of access to EPO therapy by race were addressed recently by Petronis et al. (1994).

Benefits of EPO therapy can be measured in several ways including changes in hematocrit levels and blood transfusions. Figure IV-16 shows the fraction of patients receiving any (one or more) blood transfusions by quarter for 1989 through 1993. Following the introduction of EPO in July 1989, there has been a remarkable reduction in the fraction of hemodialysis patients receiving transfusions in a quarter, i.e. from 16 percent to 2 percent.

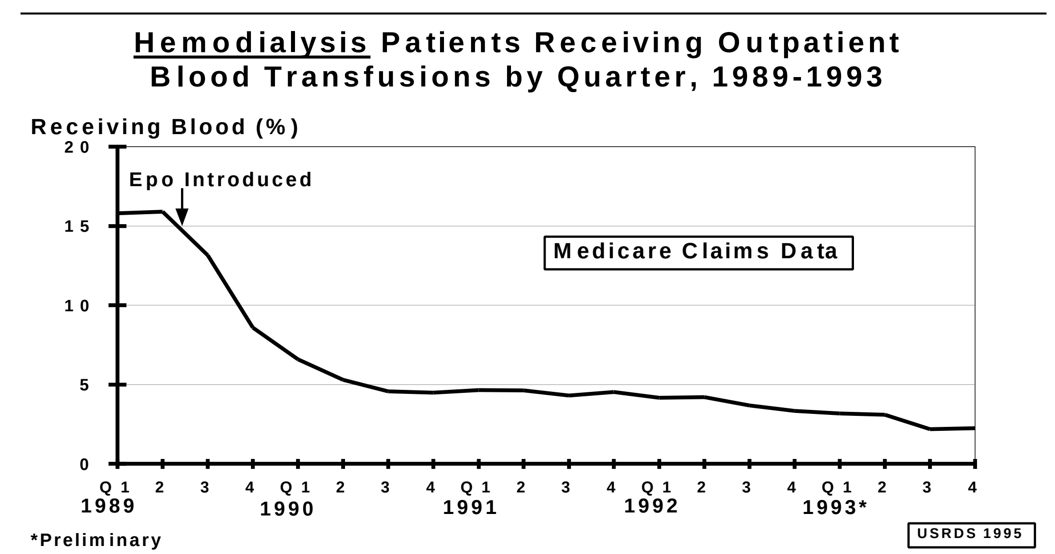

Figure IV-16

Hemodialysis Patients Receiving Outpatient Blood Transfusions by Quarter, 1989-93. From the Quarterly Dialysis Record which reports data from outpatient institutions only. (See Technical Notes, Chapter XV for details).

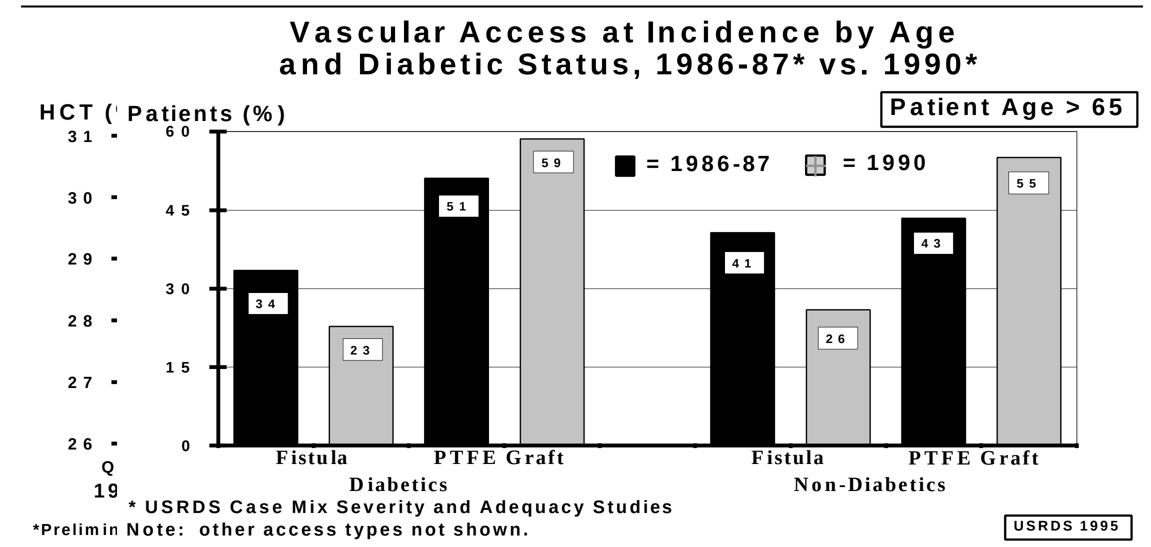

Figure IV-17 / Figure IV-18

Center Hemodialysis Patients Receiving EPO, center HD patients only: mean (X) and median (M) dose per Medicare administration, by Quarter 1989-93, and average hematocrit (HCT) during the same time period. From the Quarterly Dialysis Record which reports data from outpatient institutions only. (See Technical Notes, Chapter XV for details).

Vascular Access at Incidence by Age, 1986-87 vs 1990. From USRDS Case Mix Adequacy and Severity Studies.

For Medicare patients treated with EPO, the hematocrit is reported to HCFA on a billing period basis, typically monthly. Figure IV-17 shows the average hematocrit and the average ($\bar{X}$) and median dose (M) of EPO per administration by quarter for 1989 through 1993. The dates for EPO introduction and change in payment from a per administration to a per dose basis (January 1991) are indicated in this figure. The EPO dose showed an increase since the fall of 1990, which began one quarter before the change in payment and reporting occurred. At the end of 1993 the median dose was 4,000 units per administration with a mean of almost 5,000 units (1993 data are preliminary). The most recent average dose was below that used in the phase II clinical trial (Eschbach). The difference between the mean and the median dose in figure IV-17 is likely due to outlier values of high doses. Since the frequency of administration may have changed over time, a better measure of the actual dose would be the dose per week or per month.

Among EPO treated patients the hematocrit level increased on average by 3 percentage points overall and by 0.7 percentage points per year during 1991, 1992 and 1993. Parenteral iron therapy may reduce the EPO dose requirement in some patients (Van Wyck) and is necessary for patients not tolerating oral iron. Therefore, the unavailability of parenteral iron during 1991 and the first half of 1992 is also indicated in Figure IV-17.

Several additional factors may influence the magnitude of the rise in hematocrit in addition to the weekly dose of EPO, including the characteristics of the patients entering the treated pool, and possibly the adequacy of the delivered dialysis dose, blood loss during dialysis, aluminum toxicity and other factors.

Vascular Access Utilization

Several forms of vascular access are in use for maintenance hemodialysis. Access complications are among the most common indications for hospitalization among hemodialysis patients (see chapter X). Therefore, vascular access utilization deserves further evaluation as is planned in the USRDS Dialysis Morbidity and Mortality Study which is being fielded during 1995 and 1996.

The two USRDS Special Studies (Case Mix Severity Study of 1986/87 and Case Mix Adequacy Study of 1990/91) collected information about the type of vascular access as used at one month after the start of ESRD therapy in 1986/87 and 1990.

The arterio-venous fistula (Brescia-Cimino shunt) and the synthetic PTFE (polytetra-fluroethylene) vascular graft accounted for over 80 percent of early vascular accesses and are analyzed here. Patients with diabetic ESRD and elderly patients can be expected to be more likely to require a PTFE graft due to their peripheral vascular disease.

The analyses presented in Figure IV-18 describe the distribution of the two major types of access for patients over age 65 years from the study of 1986-87 and 1990 incident patients by diabetic status. These analyses had to be adjusted for the fact that incident patients of 1990 had to be alive and on in-center hemodialysis on December 31, 1990 in order to be selected for study. Therefore, the same rule was applied for the 1986/87 sample, i.e. incident patients of 1986 or 1987 who died or changed modality before the end of the incidence calendar year were also excluded from the 1986-87 sample for these comparative analyses. It is clear from this figure that the fraction with AV fistula decreased during the 3 to 4 year time span by about one third or by 11 to 15 percentage points, while the fraction with PTFE graft increased by 16 to 28 percent or by 8 to 12 percentage points.

Figure IV-18 shows similar trends over time by diabetic status. During the earlier period, diabetics had a large predominance of PTFE grafts (51 versus 34 percent), while non-diabetics had similar fractions for PTFE and fistulae (43 and 41 percent). However, by 1990 both groups had a more than two fold excess of PTFE use compared to fistula use. For patients under the age of 65 years similar patterns and time trends have been detected confirming the preliminary analyses described in the USRDS 1994 Annual Data Report. The impact of these new trends on vascular access complications deserves future study, particularly since previous studies have suggested that PTFE grafts are associated with higher failure rates than AV fistulae (Windus).

Average dialysis blood flow rates were assessed among prevalent patients in the USRDS Case Mix Adequacy Study by type of vascular access. As shown in Figure IV-19, the prescribed blood flow rates were similar for PTFE grafts and AV fistulae in 1991 but lower for other accesses. The latter category includes temporary access, which tend to not permit high blood flow rates. The impact of vascular access on hospitalization and cost is also being studied in the USRDS and analytical results are presented in Chapter X.

References:

Braun WE. Long-term complications of renal transplantation. Kidney Int 1990; 37:1363-1378.

Daugirdas JT. The pre:post dialysis plasma urea nitrogen ratio to estimate Kt/V and NPCR: Mathematical modeling. Int J Artif Organs 1989; 12:411-419.

Evans RW, Blagg CR, Bryan FA. A social and demographic profile of hemodialysis patients in the United States. JAMA 1981; 245:491.

Evans RW, Manninen DL, Garrison LP, Jr., Hart LG, Blagg CR, Gutman RA, Hull AR, Lowrie EG. The

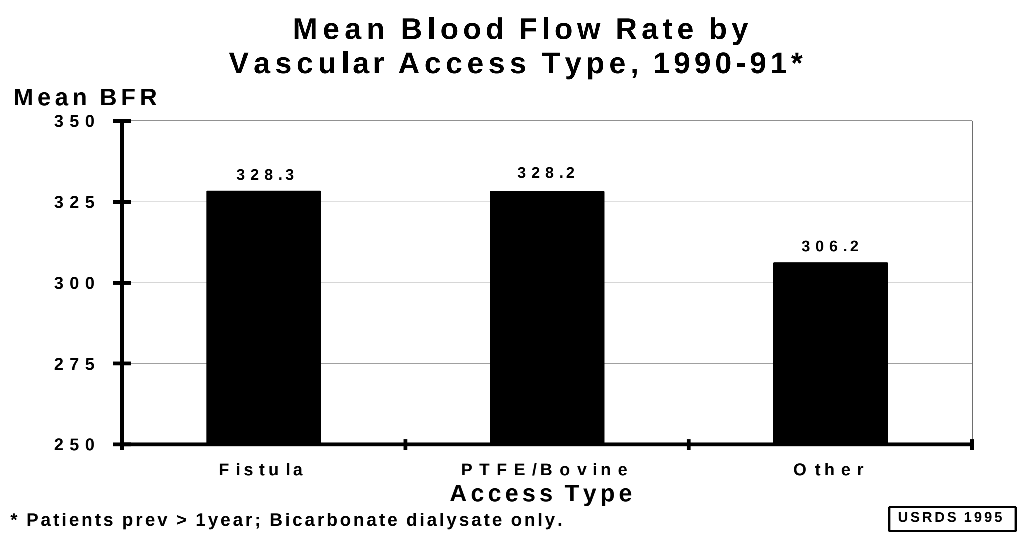

Figure IV-19

Mean Blood Flow Rate by Vascular Access Type, Center HD patients only, 1990-91. Medicare Patients only. From the USRDS Case Mix Adequacy Study.

quality of life of patients with end-stage renal disease. N Engl J Med 1985; 312:553-559.

Fox RC, Swazey JP. The Courage to Fail: A Social View of Organ Transplants and Dialysis. 2d rev. ed. Chicago: University of Chicago Press, 1979.

Gaylin DS, Held PJ, Port FK, Hunsicker LG, Wolfe RA, Kahan BD, Jones CA, Agodoa LYC. The impact of comorbid factors on access to renal transplantation. JAMA 1993; 269:603-608.

Gotch FA, Sargent JA. A mechanistic analysis of the National Cooperative Dialysis Study. Kidney Int 1985; 28:526-534.

Hakim RM, DepnerTA, Parker TF. Adequacy of hemodialysis. Am J Kidney Dis 1992; 20: 107-123.

Hamilton D. Kidney transplantation: a history. In: Morris PJ, ed. Kidney Transplantation: Principles and Practice. Grune and Stratton, London, 1984.

Health Care Financing Administration. Proposed rule: prospective reimbursement for dialysis services. Fed Reg 1982; 42:6556-6575.

Held PJ, Pauly MV, Bovbjerg RR, Newmann JM, Salvatierra O, Jr. Access to kidney transplantation: Has the United States eliminated income and racial differences? Arch Intern Med 1988; 148:2594-2600.

Held PJ, Levin NW, Bovbjerg RR, Pauly MV, Diamond LH. Mortality and duration of hemodialysis treatment. JAMA 1991; 265: 871-875.

Held PJ, Kahan BD, Hunsicker LG, Liska D, Wolfe RA, Port FK, Gaylin DS, Garcia JR, Agodoa LYC, Krakauer H. The impact of HLA mismatches on the survival of first cadaveric kidney transplants. N Engl J Med 1994; 331: 765-770.

Held PJ, Carroll CE, Liska DW, Turenne MA, Port FK. Hemodialysis therapy in the United States: What is the dose and does it matter? Am J Kidney Dis 1994; 24: 974-980.

Iwaki Y, Cecka JM, Terasaki PI. The transfusion effect in cadaver kidney transplants—yes or no? Transplantation 1990; 49:56-59.

Kahan BD, Van Curen CT, Flechner SM, Jarowenko M, Yasumura T, Rogers AJ, Yoshimura N, LeGrue S, Drath D, Kerman RH. Clinical and experimental studies with cyclosporine in renal transplantation. Surgery 1985; 97:125-131.

Kramer P, Broyer M, Brunner FP, Brynger H, Challah S, Oules R, Rizzoni G, Selwood NH, Wing AJ, Balas EA. Combined report on regular dialysis and transplantation in Europe, XIV, 1983. Proc EDTA-ERA 1984; 21:5-65.

Merion RM, White DJG, Thiru S, Evans DB, Calne RY. Cyclosporine: five years' experience in cadaveric renal transplantation. N Engl J Med 1984; 310:148-154.

Murray JE, Merrill JP, Harrison, JH. Renal homotransplantation in identical twins. Surg Forum 1955; 6:432-435.

National Institutes of Health: Morbidity and Mortality in Dialysis. NIH Consensus Statement 1993; 11(2):1-33.

Opelz G for the Collaborative Transplant Study. HLA matching and transplant survival: effect of HLA matching in 10,000 cyclosporine-treated cadaver kidney transplants. Transpl Proc 1987; 19:641-646.

Peters PC. Dialysis and transplantation: the past. Semin Nephrol 1982; 2:79-89.

Petronis KR, Carroll CE, Held PJ, Port FK. Effect of race on access to recombinant human erythropoietin in long-term hemodialysis patients. JAMA 1994; 271: 1760-1763.

Port FK. Effect of co-morbid conditions on hemodialysis mortality. Presented at clinical Science Symposium. J Am Soc Nephrol 1993; 4: 36P.

Prottas JM. Shifting responsibilities in organ procurement: a plan for routine referral. JAMA 1988; 260:832-833.

Rettig RA. The Federal government and social planning for end-stage renal disease: past, present, and future. Semin Nephrol 1982; 2:111-133.

Rettig RA, Levinsky RA (eds): Kidney Failure and the Federal Government, National Academy Press, Washington DC, 1991.

Twardowski ZJ. Peritoneal dialysis: glossary III. Perit Dial Int 1990; 10:173-175.

United States Renal Data System. Characteristics of dialysis prescription in the U.S., 1986-87. Am J Kidney Dis 1992; 20(Suppl.2):39-47.40-6

United States Renal Data System. Patient selection to peritoneal dialysis versus hemodialysis according to comorbid conditions. Am J Kidney Dis 1992; 20(Suppl.2): 20-26.

United States Renal Data System. USRDS 1991 Annual Data Report. National Institutes of Health, National Institutes of Diabetes and Digestive and Kidney Diseases. Bethesda, MD, 1991.

United States Renal Data System. USRDS 1993 Annual Data Report. National Institutes of Heath, National Institute of Diabetes and Digestive and Kidney Diseases. Bethesda, MD. 1993.

Van Wyck DB, Stivelman JC, Ruiz J, Kirlin LF, Katz MA, Ogden DA. Iron status in patients receiving erythropoietin for dialysis-associated anemia. Kidney Int 1989; 35:712-716.

Webb RL, Port FK, Gaylin DS, Agodoa LY, Greer J, Blagg CR. Recent trends in cadaveric renal transplantation. In: Terasaki PI, ed. Clinical Transplants 1990. UCLA Tissue Typing Laboratory, Los Angeles, 1991: 75-87.

Windus DW. Permanent vascular access: A nephrologist's view. Am J Kidney Dis 1993; 21: 457-471.