Vascular access use in Europe and the United States: Results from the DOPPS

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Vascular access use in Europe and the United States: Results from the DOPPS.

Background. A direct broad-based comparison of vascular access use and survival in Europe (EUR) and the United States (US) has not been performed previously. Case series reports suggest that vascular access practices differ substantially in the US and EUR. We report on a representative study (DOPPS) which has used the same data collection protocol for >6400 hemodialysis (HD) patients to compare vascular access use at 145 US dialysis units and 101 units in five EUR countries (France, Germany, Italy, Spain, and the United Kingdom).

Methods. Logistic analysis evaluated factors associated with native arteriovenous fistula (AVF) versus graft use or permanent access versus catheter use for prevalent and incident HD patients. Times to failure for AVF and graft were analyzed using Cox proportional hazards regression.

Results. AVF was used by 80% of EUR and 24% of US prevalent patients, and was significantly associated with younger age, male gender, lower body mass index, non-diabetic status, lack of peripheral vascular disease, and no angina. After adjusting for these factors, AVF versus graft use was still much higher in EUR than US (AOR = 21, P < 0.0001). AVF use within facilities varied from 0 to 87% (median 21%) in the US, and 39 to 100% (median 83%) in EUR. For patients who were new to HD, access use was: 66% AVF in EUR versus 15% in US (AOR = 39, P < 0.0001), 31% catheters in EUR vs. 60% in US, and 2% grafts in EUR vs. 24% in US. In addition, 25% of EUR and 46% of US incident patients did not have a permanent access placed prior to starting HD. In EUR, 84% of new HD patients had seen a nephrologist for >30 days prior to ESRD compared with 74% in the US (P < 0.0001); pre-ESRD care was associated with increased odds of AVF versus graft use (AOR = 1.9, P = 0.01). New HD patients had a 1.8-fold greater odds (P = 0.002) of starting HD with a permanent access if a facility’s typical time from referral to access placement was ≤2 weeks. AVF use when compared to grafts was substantially lower (AOR = 0.61, P = 0.04) when surgery trainees assisted or performed access placements. When used as a patient’s first access, AVF survival was superior to grafts regarding time to first failure (RR = 0.53, P = 0.0002), and AVF survival was longer in EUR compared with the US (RR = 0.49, P = 0.0005). AVF and grafts each displayed better survival if used when initiating HD compared with being used after patients began dialysis with a catheter.

Conclusion: Large differences in vascular access use exist between EUR and the US, even after adjustment for patient characteristics. The results strongly suggest that a facility’s preferences and approaches to vascular access practice are major determinants of vascular access use.

Vascular access use is an integral and important aspect of hemodialysis treatments provided for patients with end-stage renal disease (ESRD). Two types of permanent accesses are used in hemodialysis: (1) native arteriovenous fistulas (AVF) that are formed from a patient’s endogenous vasculature, and (2) grafts that are created using either synthetic material or bovine vessels. For some practitioners, synthetic grafts are desired for ease of cannulation [1], shorter maturation times, and usefulness when a patient’s vascular anatomy does not afford construction of an AVF. However, AVF are viewed as being superior to grafts due to the much smaller number of procedures associated with AVF use, and longer overall survival [2]. Furthermore, initial results reported by Dhingra et al suggest a lower mortality risk for prevalent diabetic patients when dialyzing with an AVF compared to a graft (abstract; J Am Soc Nephrol 11:182A, 2000).

It has been reported that vascular access use among chronic hemodialysis (HD) patients differs between the United States (US) and Europe based on results of several regional studies [3–7]. However, no representative comparison of vascular access practice in Europe and the US has been performed. The present study uses data from the Dialysis Outcomes and Practice Patterns Study
(DOPPS) to examine vascular access use in the US and five European countries (France, Germany, Italy, Spain, and the United Kingdom). DOPPS is a prospective, longitudinal study of hemodialysis practices and associated outcomes. Facilities and patients are selected to provide nationally representative samples of the HD population in each country as described previously [8]. The same data collection protocol is used in all countries allowing a direct comparison of outcomes across countries and types of facilities.

The goals of the present investigation were to (1) compare the frequencies of vascular access types used by HD patients in the US and the five European countries, (2) examine patient and practice pattern characteristics that may influence vascular access use, (3) compare native arteriovenous fistula (AVF) and graft survival in the US and Europe, and (4) determine differences in placement of temporary vascular accesses for incident patients in the US and Europe.

METHODS

Data sources
Data for these analyses were restricted to ESRD patients, older than 17 years of age, receiving in-center hemodialysis, hemofiltration, or hemodiafiltration at 145 dialysis facilities in the United States (US), 21 facilities in Germany, and 20 facilities each in France, Italy, Spain, and the United Kingdom (UK). The five European countries are collectively referred to as Europe (EUR) in this paper. Although these five countries do not represent all European HD practice, they account for approximately 84% of all HD patients in the European Union according to a recent report of the European Renal Registry and National Registries for the year 1995 [9].

United States data for this analysis were collected from July 1996 to October 2000, and data from EUR were gathered from July 1998 to October 2000. Nationally representative samples were obtained using randomized patient selection with ongoing longitudinal data collection as described previously [8].

Vascular access data were collected for each patient at entry into the study and updated whenever a vascular access-related event occurred. Vascular access information included type of access, placement location, creation date, date of first use, and dates of failure. Vascular access-related infections or procedures were also recorded.

Classification of vascular access types
Vascular accesses were reported as one of six types: native arteriovenous fistula (AVF), synthetic graft, bovine graft, tunneled central vein catheter, untunneled temporary catheter, or other type. Temporary catheters were defined as any type or brand of uncuffed, percutaneously placed, central vein dialysis catheter. In analyses in which AVF are compared to grafts, synthetic grafts and bovine grafts were combined together to form the “graft” group. Bovine grafts comprised 3 to 4% of all grafts used by HD patients in the US and EUR.

Description of cross-sectional and incident patient samples
The types of vascular access in use were described for the cross-section of all patients (prevalent) enrolled at the start of the study and for new (incident) HD patients enrolled anytime during the study. Patients were classified as incident patients if their study enrollment date was within five days of their first HD treatment for ESRD. For the incident samples in the US and EUR, greater than 90% of patients were on dialysis for one day or less when entering DOPPS. Therefore, the access in use at study start for these patients is equivalent to the access used for the patient’s first HD treatment.

Statistical analysis

Predictors of access use. Logistic regression was used to model the patient characteristics associated with the type of access used for HD at the time of study entry. Three different outcomes were considered: (1) AVF versus graft use among prevalent patients, (2) AVF versus graft use among incident HD patients at time of study entry, and (3) permanent vascular access versus catheter use among incident patients at time of study entry. In the case of AVF versus graft comparisons, other access types were excluded from the analyses. Predictors of type of access are indicated in the Results section for each model.

Access survival analyses. Cox proportional hazards regression was used to model time to first vascular access failure among incident HD patients. Time to failure was calculated as the time from first use until first failure. Failure was defined as any reported event (such as thrombosis) that resulted in an access no longer able to function for HD, even though the access may be usable at a later time if successfully salvaged by subsequent declotting or revision procedures. Observations were censored when a patient departed from the facility or the last day of known access follow-up. Models were adjusted for the following covariates: age, gender, diabetes mellitus, peripheral vascular disease, body mass index, and continent (that is, EUR vs. US). For particular comparisons, models based on data subsets were used. For example, AVF versus graft survival was compared only in US patients, and EUR versus US comparisons were restricted to AVF because there were too few grafts in EUR to generate meaningful event rates.

For plotting all survival curves, survival estimates for EUR were made relative to the US mean values for the covariates of age, gender, diabetes mellitus, peripheral vascular disease, and body mass index so that all survival
curves are comparable, and differences between curves are attributable to factors other than the covariates. Graphic analyses confirmed the validity of the proportional hazards assumption.

All statistical analyses were performed using SAS version 6.12. Logistic regression analyses employed the GENMOD procedure with a binomial error distribution and logit link function. Facility clustering effects in logistic regression models were accounted for using a “repeated” statement specifying facility-level clustering and an exchangeable correlation matrix. Cox regression analyses employed the PHREG procedure. Facility clustering effects in these analyses were addressed using robust standard error estimates based on the sandwich estimator [10] with an independent working correlation.

RESULTS
Vascular access use among prevalent HD patients in EUR and the US

Demographic and comorbid characteristics at the time of study entry are shown in Table 1 for a cross-sectional sample of HD patients in EUR and the US. The US was significantly (P < 0.05) different from EUR with regard to all listed comorbid and demographic characteristics, except for age (P = 0.78). Because of these differences in patient mix between EUR and the US, these demographic and comorbid characteristics were included as covariates in adjusted models of vascular access use. Differences between the US and EUR also were seen in the proportion of patients with hypertension, myocardial infarction, congestive heart failure, and chronic obstructive pulmonary disease, but these comorbidities were not found to be significantly related to vascular access use among prevalent patients. The values for age, diabetes mellitus as primary cause of ESRD, and proportion of female and black patients in the US-DOPPS sample are very similar to the values reported for the 1997 US population of in-center HD patients by the U.S. Renal Data System [11]. Comparable information is not available for EUR from other published sources.

The pattern of vascular access use among prevalent HD patients revealed much greater utilization of AVF in EUR compared with the US (Table 2). In EUR, AVF accounted for 80% of all accesses, with 10% of patients using grafts. High AVF use was seen in all five EUR countries, ranging from 67% in the United Kingdom to 90% in Italy. In contrast, grafts were the predominant access type in the US, comprising 58% of all accesses, with 24% of US patients using an AVF. Catheter use was 17% in EUR versus US 21%

### Table 1. Demographic characteristics and baseline comorbidities of a cross-sectional sample of patients in the United States (US) and Europe (EUR) at study start

<table>
<thead>
<tr>
<th>Covariates</th>
<th>US (N = 3882)</th>
<th>EUR (N = 2597)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age years, mean</td>
<td>60.5 ± 15.5†</td>
<td>60.7 ± 15.2‡</td>
<td>0.78</td>
</tr>
<tr>
<td>Female %</td>
<td>47</td>
<td>43</td>
<td>0.03</td>
</tr>
<tr>
<td>Blacks %</td>
<td>38</td>
<td>1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Diabetes mellitus %</td>
<td>46</td>
<td>22</td>
<td>0.0001</td>
</tr>
<tr>
<td>Diabetes mellitus as primary cause of ESRD %</td>
<td>41</td>
<td>17</td>
<td>0.0001</td>
</tr>
<tr>
<td>Peripheral vascular disease %</td>
<td>23</td>
<td>19</td>
<td>0.0001</td>
</tr>
<tr>
<td>Body mass index kg/m², mean</td>
<td>25.1 ± 5.9†</td>
<td>24.1 ± 4.7†</td>
<td>0.0001</td>
</tr>
<tr>
<td>History of angina pectoris %</td>
<td>37</td>
<td>25</td>
<td>0.0001</td>
</tr>
<tr>
<td>Years on HD, mean</td>
<td>3.4</td>
<td>5.1</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

EUR values were weighted according to the number of HD patients in each country divided by the total number of hemodialysis (HD) patients in the 5 EUR countries based on information in [9].

† Standard deviation; P values are for the comparison between US and EUR.

### Table 2. Anteriovenous fistula (AVF), graft, and catheter use among prevalent and incident hemodialysis (HD) patients in Europe (EUR) and the United States (US)

<table>
<thead>
<tr>
<th>Access use for prevalent HD patients</th>
<th>Access use for incident HD patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US</strong></td>
<td><strong>EUR</strong></td>
</tr>
<tr>
<td>AVF</td>
<td>Grafts</td>
</tr>
<tr>
<td>US</td>
<td>24</td>
</tr>
<tr>
<td>EUR</td>
<td>80</td>
</tr>
<tr>
<td>France</td>
<td>77</td>
</tr>
<tr>
<td>Germany</td>
<td>84</td>
</tr>
<tr>
<td>Italy</td>
<td>90</td>
</tr>
<tr>
<td>Spain</td>
<td>82</td>
</tr>
<tr>
<td>UK</td>
<td>67</td>
</tr>
</tbody>
</table>

The distribution of AVF, grafts, and catheters is shown separately for prevalent and incident HD patients in the US, EUR, and the countries comprising EUR. Catheters include both tunneled and untunneled central vein catheters. Values for EUR, if weighted by the proportion of HD patients in each country, were found to be very similar to the unweighted values shown in the table below. Access use by incident patients is at the time of initiating HD. AVF were placed in the lower arm for 74% of US prevalent patients and 79% of EUR prevalent patients. For incident patients, tunneled catheters comprised 25% of catheters in EUR and 52% of catheters in the US. For prevalent patients, tunneled catheters comprised 69% of catheters in EUR and 59% of catheters in the US.

### Table 3. Adjusted odds ratios for the probability of arteriovenous fistula (AVF) versus graft use among prevalent hemodialysis (HD) patients in Europe (EUR) and the United States (US)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>AOR*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female versus male</td>
<td>0.40</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Peripheral vascular disease (yes vs. no)</td>
<td>0.68</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes mellitus (yes vs. no)</td>
<td>0.76</td>
<td>0.0007</td>
</tr>
<tr>
<td>History of angina pectoris (yes vs. no)</td>
<td>0.89</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI kg/m² (for every 1 unit increase)</td>
<td>0.92</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Per year on HD</td>
<td>0.99</td>
<td>0.18</td>
</tr>
<tr>
<td>EUR versus US</td>
<td>21</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* AOR, adjusted odds ratio of AVF versus graft use; BMI, body mass index; (N = 4849)

AOR values >1.0 indicate that the covariate is associated with increased odds of AVF use.
use was found to be strongly related \((P < 0.01)\) to younger age, male gender, non-diabetic status, lower body mass index, no history of angina, and absence of peripheral vascular disease (PVD). Although the probability of AVF use was not associated with the number of years of HD treatment when analyzed across all countries \((AOR = 0.99, P = 0.18)\), a continent-specific analysis indicated that years of HD treatment had opposite effects upon AVF use in EUR \((AOR = 0.93\) for every year of HD, \(P < 0.0001)\) compared with the US \((AOR = 1.02\) for every year of HD, \(P = 0.04)\). Allon et al recently showed AVF use for prevalent patients in the US HEMO study to be significantly related to these characteristics, except angina, which was not tested \([12]\). The HEMO study also showed coronary artery disease to be significantly related to AVF use. Our analysis found that coronary artery disease (CAD) was significantly associated with AVF use if history of angina was excluded from the model \((AOR = 0.85, P = 0.03)\), but CAD was not significant if angina was included in the model \((AOR = 0.96, P = 0.63)\). Therefore, the effect of coronary artery disease on AVF use is explained by the angina variable in our analytical model.

The above analysis model also indicated that the likelihood of AVF versus graft use was much greater in EUR than in the US \((AOR = 21, P < 0.0001)\). Parameter estimates obtained from a similar logistic model restricted to EUR practice were applied to the US patient mix, and estimated that 79% of US patients would be expected to use an AVF if the EUR practice of access placement was applied to the US patient mix of age, gender, diabetes mellitus, peripheral vascular disease, body mass index, history of angina, and years on HD. In conclusion, the analytical models indicate that AVF versus graft use is associated with certain patient characteristics, but a large difference remains in AVF use between the US and EUR that is not accounted for by differences in these patient characteristics.

Arteriovenous fistulae use among prevalent patients was also compared in EUR and the US for two patient subgroups with different levels of associated comorbidity (Fig. 1). The first subgroup consisted of non-diabetic patients, age 18 to 54 years old, without peripheral vascular disease and without coronary artery disease. In EUR, 76% of females and 89% of males in this subgroup were using an AVF compared with 41% of US males and 22% of US females. The second subpopulation consisted of diabetic patients, >54 years of age, who have peripheral vascular disease and/or coronary artery disease. AVF use was high for this group of patients in EUR, ranging from 64% for females to 82% for males. However in the US, only 22% of males and 10% of females used an AVF in this group. The results of the subpopulation analysis demonstrate that the high level of AVF use in EUR is seen both for patients of low or high comorbidity levels. AVF use in the US is substantially lower than EUR, even for relatively young, non-diabetic patients without coronary artery disease.

The percentage of AVF use in different dialysis units in each country was also determined (Fig. 2). EUR dialysis units displayed a range of AVF use, varying from 39% in some facilities to 100% in others, with a median facility value of 83% AVF use. In EUR, 31% of dialysis units had an AVF use rate of \(\geq 90\%\), with 100% of patients using an AVF in 25% of Italian dialysis units. US dialysis units displayed rates as low as 0% AVF use in some dialysis units but as high as 87% in other facilities, with a median facility value of 21% AVF use. These
results indicate that despite a moderately low overall use of AVF in the US, some facilities have achieved a high rate of AVF use comparable to that seen for many EUR facilities. However, one-quarter of US dialysis units had very low AVF use in which only 0 to 12% of patients dialyzed with an AVF within each of these units. In the HEMO study, Allon et al recently indicated a similar large variation of 12 to 61% AVF use for 15 university-affiliated clinical centers in the US [12].

**Vascular access use among patients new to hemodialysis**

Similar to the prevalent patient sample, large differences were seen in AVF use by new (incident) HD patients in the US compared with EUR. AVF were used by 66% of incident HD patients in EUR when starting HD, with 2% of EUR incident patients using a graft (Table 2). In four of the five EUR countries, AVF use ranged from 60 to 83% among new HD patients, whereas in the United Kingdom 47% of incident patients dialyzed with an AVF when starting HD. In contrast, 60% of US incident patients began dialysis with a catheter, with only 15% using an AVF and 24% using a graft.

Pre-ESRD care was compared between EUR and the US to determine its effect upon access use at the start of HD (Table 4). Data from facility staff indicated that 84% of EUR patients and 74% of US patients had seen a nephrologist >30 days prior to ESRD. Patients reported a similar pattern of moderately greater short-term pre-ESRD care provided by EUR dialysis units. However, patient responses also indicated a substantially larger proportion of EUR patients receiving long-term pre-ESRD care, with 69% of EUR patients seeing a nephrologist for at least one year prior to ESRD compared with 44% in the US.

Various relationships between early nephrologic care and the type of access used by incident patients when starting HD were examined. For patients receiving nephrologic care >30 days prior to ESRD, 79% of EUR patients and 48% of US patients ($P < 0.0001$) used a permanent

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**Table 4. Amount of time prior to end-stage renal disease (ESRD) that patients are first seen by a nephrologist in Europe (EUR) and the United States (US), as reported by the study coordinator or by patients**

<table>
<thead>
<tr>
<th>Data source</th>
<th>Type of pre-ESRD care</th>
<th>EUR % of incident patients</th>
<th>US % of incident patients</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study coordinator</td>
<td>Patient seen by nephrologist &gt;30 days prior to ESRD</td>
<td>84</td>
<td>74</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Study coordinator</td>
<td>Patient seen by nephrologist &gt;4 months prior to ESRD</td>
<td>80</td>
<td>68</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Study coordinator</td>
<td>Patient seen by nephrologist &gt;1 year prior to ESRD</td>
<td>69</td>
<td>44</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

| Patient | Patient seen by nephrologist >30 days prior to ESRD       | 87                         | 80                        | <0.0001   |
| Patient | Patient seen by nephrologist >4 months prior to ESRD     | 80                         | 68                        | <0.0001   |
| Patient | Patient seen by nephrologist >1 year prior to ESRD       | 69                         | 44                        | <0.0001   |

In US, $N = 1813$ for the Study Coordinator analysis, and $N = 1015$ for the Patient analysis. In EUR, $N = 888$ for the Study Coordinator analysis, and $N = 706$ for the Patient analysis.
Table 5. Adjusted odds ratios for the probability of arteriovenous fistula (AVF) versus graft use, or permanent access versus temporary access use in incident patients at start of hemodialysis (HD) in Europe (EUR) and the United States (US)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Model a: AVF versus graft use</th>
<th></th>
<th>Model b: Permanent access versus temporary access use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR</td>
<td>P value</td>
<td>AOR</td>
</tr>
<tr>
<td>Age for every 10 years older</td>
<td>0.92</td>
<td>0.14</td>
<td>1.06</td>
</tr>
<tr>
<td>Female vs. male</td>
<td>0.39</td>
<td>0.0001</td>
<td>0.82</td>
</tr>
<tr>
<td>Diabetes mellitus (yes vs. no)</td>
<td>0.97</td>
<td>0.84</td>
<td>1.14</td>
</tr>
<tr>
<td>PVD (yes vs. no)</td>
<td>0.80</td>
<td>0.35</td>
<td>0.92</td>
</tr>
<tr>
<td>History of angina (yes vs. no)</td>
<td>0.97</td>
<td>0.85</td>
<td>0.81</td>
</tr>
<tr>
<td>Pre-ESRD care (yes vs. no)</td>
<td>1.95</td>
<td>0.01</td>
<td>6.1</td>
</tr>
<tr>
<td>If time from referral to access placement is ≥2 weeks (yes vs. no)</td>
<td>0.87</td>
<td>0.57</td>
<td>1.76</td>
</tr>
<tr>
<td>If time from AVF creation until first cannulation is ≥2 months (yes vs. no)</td>
<td>1.24</td>
<td>0.31</td>
<td>0.87</td>
</tr>
<tr>
<td>Number of surgeons placing permanent accesses in a dialysis unit (for every 3 surgeon increase)</td>
<td>1.00</td>
<td>0.98</td>
<td>1.15</td>
</tr>
<tr>
<td>If surgery trainees perform/assist in placing permanent access (yes vs. no)</td>
<td>0.61</td>
<td>0.04</td>
<td>0.83</td>
</tr>
<tr>
<td>EUR versus US</td>
<td>39</td>
<td>0.0001</td>
<td>4.8</td>
</tr>
</tbody>
</table>

PVD is peripheral vascular disease; Pre-ESRD care refers to whether patient saw a nephrologist >30 days prior to ESRD; logistic models were adjusted for facility clustering effects.

1 Model (a), AOR values >1.0 indicate increased odds of AVF use; N = 967
2 Model (b), AOR values >1.0 indicate increased odds of permanent access use; N = 2073
3 Denotes a facility level characteristic provided by the study coordinator at each dialysis unit.

access for their first HD treatment (data not shown). This result indicates that EUR pre-ESRD practice is substantially more successful than US pre-ESRD practice in establishing a permanent access that is functional for a patient’s first HD treatment, even though a large proportion of EUR patients start HD with an AVF. Furthermore, 46% of US incident patients and 25% of EUR incident patients did not have a permanent access placed prior to starting dialysis, even though 55% of these patients in both EUR and the US had seen a nephrologist >30 days prior to ESRD (data not shown).

A logistic model was used to evaluate the relationships of various patient characteristics and treatment practices upon AVF versus graft use by new ESRD patients when starting HD (Table 5). AVF use was significantly less likely if patients were female (AOR = 0.39, P < 0.0001) or if surgery trainees assisted or performed vascular access placements for the dialysis unit (AOR = 0.61, P = 0.04). Patient age, diabetes, peripheral vascular disease, history of angina, a facility’s usual time from referral to access placement, a facility’s typical time from AVF creation until first cannulation, and number of surgeons were not significantly related to whether patients began HD with an AVF versus a graft. However, AVF use was substantially more likely than graft use if patients received nephrologic care >30 days prior to ESRD (AOR = 1.95, P = 0.01) or if treated in EUR compared to the US (AOR = 39, P < 0.0001). This latter result indicates that there continues to be a large difference in AVF versus graft use among incident patients in EUR and US even after adjustment for age, gender, diabetes mellitus, peripheral vascular disease, history of angina, pre-ESRD care >30 days prior to ESRD, time from referral to access creation, typical time until AVF are first cannulated, use of surgery trainees, or the number of surgeons placing permanent vascular accesses for patients in a dialysis unit.

Permanent access versus temporary access comparisons revealed that permanent vascular access use at start of HD is greater in EUR than in the US (AOR = 4.8, P < 0.0001) and is less likely for female patients (AOR = 0.82, P = 0.05) or for patients having a history of angina (AOR = 0.81, P = 0.04; Table 5). In addition, permanent access use at the start of HD was substantially more likely if patients were treated in a dialysis unit that typically creates an access within two weeks of referral (AOR = 1.76, P = 0.002) or if patients saw a nephrologist >30 days prior to ESRD (AOR = 6.1, P < 0.0001).

Subgroup analyses were used to explore access use in EUR versus US further. Three different incident HD patient subpopulations were analyzed (Fig. 3). The first two groups were non-diabetic white males of (group i) age 18 to 54 years, or (group ii) age >54 years, and the third group was white diabetic females >17 years old (group iii). The race restriction was used to make comparisons across continents more easily, and the relatively smaller number of patients in the diabetic female subgroup limited further division of this subgroup into different age categories. The results of this analysis indicate that in the US, AVF use among the two incident male non-diabetic groups was 24% and 19%, respectively, and decreased to 11% for incident female diabetic patients.
In contrast, AVF use was high for all three groups in EUR, ranging from 63% for diabetic females to 77% for non-diabetic males aged 18 to 54 years.

In the above analysis, grafts accounted for <0.5% of all accesses among EUR non-diabetic males and 4% of accesses among EUR diabetic females. In contrast for the US, 18% of non-diabetic males and 25% of diabetic females used grafts when starting HD. These results further indicate that grafts are seldom used as the choice of a permanent access for incident patients in EUR, even among diabetic female patients.

**Type of physician placing permanent vascular accesses**

Country variation was observed concerning the type of physician who generally places permanent vascular accesses for HD patients. In France, Germany, Spain, the UK, and the US, 65 to 89% of permanent vascular accesses were placed by a vascular surgeon. However, in Italy, approximately 80% of permanent access placements were performed by a nephrologist, similar to the recent report by Bonucchi et al [6]. Logistic models of AVF versus graft use at start of HD did not find a significant relationship between AVF use and the type of physician placing the permanent vascular access with regard to vascular surgeons, general surgeons, transplant surgeons, or urologists (P value range, 0.48 to 0.55 depending on physician type, data not shown). However, if a nephrologist was the primary type of physician placing permanent vascular accesses for patients in a dialysis unit, then 100% of incident patients who began HD with a permanent access were found to use an AVF in these units (N = 74 patients). This latter practice of high AVF use associated with access placement by nephrologists was predominantly accounted for by Italian nephrologists, who comprised 96% of all nephrologists placing accesses among incident patients in the study sample.

**Permanent vascular access survival in the US and EUR**

Cox regression analyses adjusted for case-mix were used to assess AVF and graft survival among incident patients in EUR and the US. The AVF versus graft survival in Figure 4A is for incident patients who used either a graft or AVF for their first HD treatment. The estimated one-year survival probability was 68% for AVF (95% CI 59 to 77%, N = 177) and 49% for grafts (95% CI 42 to 57%, N = 251) in the US, with AVF in EUR displaying a one year survival of 83% (95% CI 78 to 89%, N = 429). The case-mix adjusted survival curves indicated substantially better survival of AVFs compared with grafts in the US [risk ratios (RR) of failure = 0.56, P = 0.0009]. In addition, AVF survival was found to be greater in EUR than in the US (RR of failure = 0.49 in EUR versus US, P = 0.0003). The small number of grafts placed among EUR incident patients precluded a survival analysis of grafts for EUR. Regarding other covariates tested in a model of AVF survival, peripheral vascular disease (RR = 3.2, P = 0.001) and female gender (RR = 2.3, P = 0.003) were associated with increased risk of AVF failure in EUR, with peripheral vascular disease possibly related to increased AVF failure also within the US (RR = 1.7, P = 0.12).

Whereas the above analysis indicates better survival of AVF compared with grafts for patients who start HD with a permanent access, the pattern of AVF versus graft survival is more complex if patients use a temporary
catheter for their first HD treatment and then the survival of a subsequently used AVF or graft is determined. In this situation, no significant difference was observed in AVF versus graft survival in the US during the first 240 days of use (RR of failure = 0.76, $P = 0.24$), whereas after this time period AVF displayed substantially better long-term survival compared with grafts (Fig. 4B).

Both in EUR and the US, AVF survival was substantially better when AVF were used for the first HD treatment compared with AVF first used after starting HD with a catheter (in EUR, RR of failure = 0.50, $P = 0.001$; in US, RR of failure = 0.63, $P = 0.03$, if AVF was used for first HD treatment). In addition, graft survival in the US was better if used for the first HD treatment versus grafts used after starting HD with a catheter (RR of failure = 0.70, $P = 0.03$).

For the above survival analyses, elective angioplasty was not included as an indication of access failure. However, a sensitivity analysis demonstrated that if elective angioplasty had been included as a failure, then the one-year AVF survival probabilities in the US and EUR would each decrease by 3% points with no change in graft survival, resulting in a small increase of 6 to 7% in the risk ratios of failure for AVF versus grafts in the US, and AVF in EUR versus the US.

**Sites of catheter placement**

The site where catheters were placed was compared for incident patients in EUR and the US (Fig. 5). In EUR, the internal jugular vein was the most commonly used site, serving for 57% of untunneled catheters and 80% of tunneled catheters. In addition, 15 to 18% of EUR catheters were placed in the subclavian vein. In the US, the subclavian vein (46%) and internal jugular vein (46%) were the most commonly used sites for untunneled catheters, with tunneled catheters placed predominantly in the internal jugular vein (62%) and the subclavian vein (36%).

Since DOPPS data collection in the US has occurred over the time period from 1996 through 2000, a time trend analysis was performed. It indicated that subclavian vein placement of catheters has decreased in the
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for the US are similar to those reported by Woods and Port [13] and Stehman-Breen et al [14].

A major question addressed during these analyses was what are the predominant factors associated with access use? Patient age, gender, diabetes, peripheral vascular disease, body mass index, and history of angina were found to be associated with access use in EUR and the US. However, after adjustment for these patient characteristics, large differences are still seen in AVF use between the US and EUR. Instead, a facility’s preference for type of access [15], and approach to vascular access and nephrologic care appear to be important factors determining access placement. For example, early nephrologic care is similar in the US and EUR, with 84% of EUR patients seeing a nephrologist >30 days prior to ESRD compared to 74% of US patients. Despite this similarity, the percentage of US patients starting HD with a permanent access is nearly one-half that of patients in EUR. In addition, for new patients receiving nephrologic care for >30 days prior to ESRD, the percentage starting HD with a permanent access was 79% in EUR compared with 48% in the US. This large difference exists despite the US practice of placing more grafts than AVF, with grafts generally perceived to mature in a shorter time. Arora et al reported a similar observation in Europe (EUR) and the United States (US).

Fig. 5. (A) Distribution of placement locations for untunneled temporary catheters used by incident patients at start of hemodialysis (HD) in Europe (EUR) and the United States (US). (N = 204 for EUR, N = 628 for US). (B) Distribution of placement locations of tunneled central vein catheters used by incident patients at start of HD in EUR and the US. (N = 71 for EUR, N = 683 for US).

US from 54% (95% CI 43 to 64%) in 1996 to 28% (95% CI 23 to 34%) in year 2000 (P < 0.01).

DISCUSSION

The direct comparison of vascular access use provided by DOPPS indicates large differences in vascular access use in EUR compared with the US. EUR vascular access placement is centered around AVF use with 66% of new ESRD patients starting HD with an AVF, and AVF use rising to 80% in EUR for all HD patients. Subgroup analyses demonstrate that EUR practice is successful in placing AVF at a high rate in a broad spectrum of patients including older diabetic female patients with coronary artery disease and/or peripheral vascular disease. Only 2% of EUR incident patients initiate HD with a graft, indicating that grafts are seldom chosen for a patient’s first permanent access in EUR.

In contrast to EUR, grafts are the predominant permanent access in the US, serving 58% of prevalent patients, and used by 24% of incident patients when starting HD. AVF are used by only 15% of US incident patients at initiation of HD, with AVF use increasing to 24% among prevalent patients in the US. These results from DOPPS...
>30 days prior to ESRD. Both in the US and EUR, further gains may be made in starting patients with a permanent vascular access if a better understanding can be gained regarding the obstacles and factors that result in patients not receiving a permanent access during the pre-ESRD period even though a nephrologist is seen more than 30 days prior to ESRD.

An important aspect of new ESRD patients starting HD with a permanent access is the process and organizational structure of the referral network for placing vascular accesses. An expedient process of ≤2 weeks from time of referral until access placement was associated with a 1.8-fold higher likelihood of new ESRD patients beginning HD with a permanent vascular access. The number of surgeons placing permanent accesses for a facility or whether AVF cannulation typically occurs within two months from the date of access creation, however, did not appear to be associated with whether incident patients began dialysis with a permanent access.

Previously, Hirth et al showed that AVF versus graft use in the US strongly differed across some geographic regions and according to patient socioeconomic status [17]. These analyses were adjusted for demographic and comorbid conditions, and suggested that factors beyond a patient’s clinical presentation may play an important role in access placement decisions. Economic factors appear not to be a strong driving force for high graft use in the US as suggested by two reports in which the annual costs for use of grafts were found to be higher than for AVF (abstract; Collins et al, *J Am Soc Nephrol* 10:203A, 1999) [18]. Furthermore, for most patients, costs for either type of access are covered by Medicare, and the differences are small concerning reimbursements to physicians for placing grafts versus AVFs.

In the present study, a large variation of 0 to 100% AVF use was seen among different dialysis units in the US and EUR. AVF use in EUR facilities varied from 39% to 100%, with 31% of EUR facilities having ≥90% of their patients dialyzing with an AVF. In addition, DOPPS data (not shown) and other reports indicate that four of the five EUR countries have a smaller percent of ESRD patients receiving peritoneal dialysis than in the US [9, 11]. Therefore, the higher rates of AVF use in EUR likely are not due to poor candidates for AVF being steered to peritoneal dialysis. The higher rates of AVF use seen in EUR suggest that in many EUR dialysis units a process of vascular access care is in place leading to successful AVF placement in a very high proportion of patients. A key question for future examination, in addition to a strong commitment to AVF placement, is what processes have these dialysis units implemented in order to be highly successful in creating AVF for their patients? Some dialysis units have reported substantial increases in AVF use through organizational changes in their approach to vascular access care [19, 20], performing pre-operative vascular mapping with greater use of brachiocephalic upper arm AVF [19, 21–23], and utilizing forearm superficial venous transposition [24]. Notably, Dr. Konner has achieved high levels of AVF use for a diverse patient population by performing detailed mapping of patient vasculature prior to AVF placement, and employing a variety of different surgical approaches to address the challenges posed by different clinical and anatomical presentations [25, 26].

A noteworthy observation during the analysis of AVF versus graft use among new HD patients in EUR and the US was the finding that the likelihood of AVF use was 40% lower in dialysis units in which surgery trainees either assisted or performed permanent vascular access placements (Table 5). Surgery trainees are used in approximately 34% of DOPPS dialysis units in both the US and EUR. These results suggest that graft placement may be emphasized to a greater extent in surgical training settings or that trainees are not adequately prepared to create functioning AVF in a diverse patient population. This may represent an opportunity for intervention and improved vascular access outcomes for patients at HD centers affiliated with surgical training programs.

In the US, 60% of new ESRD patients begin HD with a catheter compared with 31% in EUR. One of the negative effects for patients starting HD with a temporary access is revealed in comparing AVF survival in Figure 4. These results indicate that AVF and graft survival are substantially greater if used at the start of HD rather than after a patient begins dialysis with a catheter. Although there may be patient characteristics not controlled for in the survival analysis that may contribute to the access survival differences in Figure 4, these results of greater AVF and graft failure after catheter use could also be due to (1) placement location of temporary catheters that adversely affect longevity of subsequently used AVF or grafts (abstract; Young et al, *J Am Soc Nephrol* 10:223A, 1999); (2) the AVF being used before they have fully matured [27]; or (3) changes/losses in biological factors occurring once a patient begins hemodialysis with these changes leading to less favorable access maturation resulting in higher access failure rates.

Similar to several other studies [20, 28–33], our results showed greater survival of AVF compared with grafts in the US. Furthermore, AVF survival was found to be substantially better in EUR compared with the US (RR = 0.49, P = 0.0005). The reasons for this latter effect will be evaluated in future analyses.

During the past 12 years, several reports including the 1997 DOQI Guidelines have recommended that practitioners avoid placing catheters in the subclavian vein to minimize central vein stenoses and other complications that may prohibit future placement of vascular accesses on the side of the cannulation [2, 34–40]. Catheter placement in the subclavian vein differed considerably be-
between EUR and the US in the present analysis, with 15 to 18% of EUR patients starting HD with a catheter in the subclavian vein compared with 36 to 46% of US patients, depending on whether patients were using a tunneled or untunneled catheter for their first HD. Although subclavian vein placement of temporary catheters is approximately twofold higher in the US compared with EUR, the time trend analysis for the US indicates a continuing strong decline in temporary access subclavian vein placement from the values of 79% in 1993, and 66% in 1996 reported by the United States Renal Data System [41] to a current value seen in DOPPS of 28% for year 2000.

In summary, large differences in vascular access use are seen between the US and EUR that remain even after adjustment for patient mix. This large variation also is observed at the facility level from 0-100% AVF use among the aggregate of facilities within the US and EUR. Our analyses indicate that although access use is associated with particular patient characteristics, facility preferences and approaches to vascular access practice appear to be very important determinants of the type of access given to patients. An initial description of several facility treatment effects with relevance to access use has been presented. The results of these analyses strongly support the primary factors that some dialysis units have recently focused their changes upon for achieving high AVF use rates. These factors are: a strong commitment to AVF as the permanent access of choice, implementing organizational changes to minimize delays in AVF placement during the pre-ESRD period, and applying highly skilled surgical technique with variations in procedure to successfully accommodate the differences in vasculature and comorbidities presented by the patients. The challenges for future investigation will be to more closely examine the organizational structures that determine vascular access practice and how these impact access placement, access survival, patient satisfaction, cost implications for utilizing different access types, and infection, procedure, and hospitalization rates associated with use of different access types.

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