Published in final edited form as:

Am J Kidney Dis. 2009 January ; 53(1): 91–98. doi:10.1053/j.ajkd.2008.08.011.

Patterns of Use of Vascular Catheters for Hemodialysis in Children in the United States

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Abstract

Background—Arteriovenous fistulas and grafts (AVF/AVG) have been associated with improved clinical outcomes in children and adults with end-stage renal disease (ESRD) on maintenance hemodialysis (HD), but the use of vascular catheters is high. Identifying the reasons for the high prevalence of vascular catheters in children on HD is necessary to assess whether targeted interventions may increase the prevalence of AVF/AVG's.

Study Design—Retrospective cohort study.

Setting & Participants—Children younger than 18 years on HD in the 2001–2003 ESRD Clinical Performance Measures (CPM) Projects followed in the United States Renal Data System transplant files through December 31, 2004.

Predictor—Vascular access type and reasons for use of a vascular catheter.

Outcomes & Measurements—Demographic/clinical characteristics, including the reason provided for use of a vascular catheter, and the association of type of vascular access and: {1} patient size, and {2} time to kidney transplantation.

Results—Of 1,284 prevalent pediatric CPM patients examined, 529 (41%) had an AVF/AVG and 755 (59%) had a vascular catheter. Among the 755 children with a catheter, “small body size” was a commonly listed reason (N=142); 49% of these children weighed 20 kilograms or more. Among the 53 patients with catheters described as having an “AVF/AVG maturing” and present in the consecutive ESRD CPM project year, 64% had a functioning AVF/AVG the following year. For those with “transplant scheduled” listed as a reason for a vascular catheter (N=83), 69% were transplanted within 1 year and the median time to transplant was 115 days. Among all children with vascular catheters (N=755), 32.2% were transplanted within 1 year, and the median time to transplant was 264 days, compared to 21.7% and 347 days, respectively, for those with AVF/AVG's (N=529). Among the 445 incident children in this cohort, 89% had a vascular catheter at dialysis initiation.

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Limitations—Because of study design, only associations can be described.

Conclusions—Vascular catheter use among children on HD is high. This is partially explained by expeditious transplantation and technical barriers to AVF/AVG placement in small children, however only one third of patients with a vascular catheter were transplanted within 1 year. Interventions to decrease vascular catheter use in this population may be necessary.

Keywords

Pediatric; end-stage renal disease; hemodialysis; vascular access; vascular catheter; transplantation

Permanent vascular access in the form of an arteriovenous fistula or graft (AVF/AVG) is preferred for most children with end-stage renal disease (ESRD) on maintenance hemodialysis (HD) therapy.(1) Compared to AVF/AVG's, vascular catheters in children have been associated with significantly increased morbidity, including an almost 2-fold increase in hospitalization for any cause, almost 3-fold increase in vascular access complications, and almost 5-fold increase in hospitalization as a result of infection.(2) Vascular catheters are known to be associated with limited longevity in children.(3–9) Children with AVF/AVG's, as compared to vascular catheters, have been shown to have improved urea clearance and higher hemoglobin and serum albumin values.(2,10)

Although AVF/AVG's are the preferred form of access in most children on maintenance HD, the 2006 update of National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Recommendations list circumstances in which a venous catheter may be acceptable for long-term access. These circumstances include: lack of local surgical expertise to place an AVF/AVG in small children, patient size too small to support an AVF/AVG, bridging HD for peritoneal dialysis (PD) training or PD catheter removal for peritonitis, and expectation of expeditious kidney transplantation. It is recommended that serious consideration be given to placement of AVF/AVG's in children greater than 20 kilograms in size, who are expected to wait more than 1 year for a kidney transplant. If surgical expertise to place AVF/AVG's does not exist in the patient's pediatric setting, it is recommended to consult local adult-oriented surgeons with vascular access expertise to either supervise or place AVF/AVG's in children. (1)

This study describes vascular access type, including the reasons provided for use of vascular catheters, in a large cohort of children on maintenance HD within the United States. Given KDOQI recommendations, we aimed to determine if patient size and time to expected kidney transplantation were associated with vascular access type.

METHODS

Design and Setting

This is a retrospective cohort study utilizing merged data from two national databases in the United States (US): The Centers for Medicare & Medicaid Services' (CMS) ESRD Clinical Performance Measures (CPM) Project and the United States Renal Data System (USRDS), which collectively gather clinical and demographic information, as well as data regarding hospitalization of and surgery in patients maintained on HD. The ESRD CPM Project was developed in response to federal legislation requiring CMS to measure and report the quality of kidney dialysis services provided under the Medicare program. Details of the methods of data collection for the ESRD CPM Project have been reported elsewhere.(11,12) Within this project, Clinical Performance Measures (CPMs) were developed for *adult patients* based on KDOQI Clinical Practice Guidelines.(1,13–17) The USRDS maintains data on all incident and prevalent ESRD patients in the US, including demographic, laboratory, insurance, and medical

data. The USRDS collects additional data on dialysis claims and information on treatment history and hospitalization/surgery events submitted to Medicare. This data collection supports the goals of the USRDS: to characterize the ESRD population, to identify new areas for research, and to provide national data to support research by independent investigators and the missions of various government agencies. (18)

Participants and Variables of Interest

All patients aged 0 to <18 years present in the 2001, 2002, and 2003 ESRD CPM Projects were included in this analysis. The 2001 Project included children aged 12 to <18 years, and the 2002 and 2003 Projects included those 0 to <18 years maintained on HD. Patient records were then linked to the USRDS standard analytic and transplant files using the USRDS patient identification number, which is common to both databases. At the time of analysis, the USRDS transplant and transplant follow-up files were updated through December 31, 2004. Each CPM ESRD project year includes prevalent children who were alive and receiving in-center HD as of December 31 of the preceding year. For example, for the CPM ESRD 2001 Project, patients included were receiving in-center HD as of December 31, 2000. These patients had consecutive monthly data from October through December of 2000 submitted by the dialysis centers for the 2001 project year. In contrast to the adult ESRD CPM Projects, which report on a national random sample of adult HD patients, the *pediatric* ESRD CPM data collection includes *all* prevalent patients receiving in-center HD. To be included in the ESRD CPM Project, the minimum clinical data required included at least 1 of each of the following values: hemoglobin, pre- and postdialysis blood urea nitrogen, and serum albumin.

All information pertaining to demographic and clinical characteristics of the patients presented in this analysis was obtained from the ESRD CPM Project database. This includes the information regarding the main variable of interest, type of vascular access, as well as age, sex, race, height, ethnicity, cause of ESRD, dialysis vintage, levels of hemoglobin and serum albumin, and adequacy. For patients present in consecutive years of the ESRD CPM Project, demographic and clinical data from the first year the patient appears in the database is presented.

For the purposes of this analysis, vascular access type was dichotomized as vascular catheter or permanent, which includes both AVF/AVG. For patients with a vascular catheter, the ESRD CPM Project requests a reason for the vascular catheter. One or more of the following reasons may be selected: {1} AVF/AVG maturing and not ready to cannulate, {2} temporary interruption of the AVF/AVG due to clotting/revisions, {3} all AVF/AVG sites have been exhausted, {4} no AVF/AVG surgically created in patient's body at this time, {5} peripheral vascular disease, {6} patient size too small for AVF/AVG, {7} renal transplantation scheduled, {8} patient preference, {9} provider preference, and {10} other. In contrast to the 2002 and 2003 ESRD CPM Projects, the 2001 project did not provide "patient preference" or "provider preference" as choices for the reason for use of a vascular catheter as HD access. For the choice of "other" in the 2002 and 2003 Projects, a space was provided to allow a write-in explanation; in the 2001 Project, no such space was provided.

The reasons provided for use of a vascular catheter were examined in more detail when possible. For "AVF/AVG maturing", vascular access type was examined the following year for patients present in consecutive project years. For "peripheral vascular disease", underlying cause of ESRD was examined. For "patient size too small", height, weight and body surface area (Mosteller equation) were examined.(19) For all patients, the USRDS transplant file was examined for kidney transplantation. The time points used to determine the "time to transplantation" variable included January 1 of the year of a patient's first appearance in any of the 2001–2003 ESRD CPM Projects, and the date of kidney transplantation within the USRDS transplant file (updated through December 31, 2004). For example, for a patient

included in the 2001 ESRD CPM Project, data including vascular access type and reason(s) for use of a vascular catheter was collected from October–December of 2000. To provide the most conservative and accurate classification of access type and reason(s) for vascular catheter, January 1, 2001 was selected as the starting point for the “time to transplantation” analysis. Time to transplantation was examined by category of vascular access, and a subanalysis of patients with a vascular catheter and the “transplantation scheduled” reason provided was performed.

In any given CPM Project year, a subset of the examined patients is incident to HD, and the CPM ESRD Project. To characterize the type of vascular access in place among this *incident* subset, the data collection form from the ESRD CPM Project additionally inquires as to the type of vascular access present at the initiation of HD for those children who FIRST started a maintenance course of HD during January 1 – August 31 of the year of the data collection. This excludes those who have changed dialysis modality, had a newly failed transplant, or returned to dialysis after an episode of regained kidney function. For these children newly initiated to HD, the data collection form next inquires as to the type of access in use 90 days later.

Data Analysis—All available data were used to calculate means, medians, and threshold values. Single-pool Kt/V urea (spKt/V) values were calculated using the Daugirdas II formula, which has been validated in children on HD.(20–22) Causes of ESRD were dichotomized as congenital renal and/or urological versus other identified causes combined. Associations of clinical data with patient characteristics were tested by means of chi-square and 2-tailed Student t-tests. *P*-values less than 0.05 were considered significant. Data analyses were conducted using SAS, version 8.002 (SAS Institute, Cary, NC).

RESULTS

A total of 1,284 unique patients aged 0 to less than 18 years were identified in the 2001–2003 ESRD CPM Projects. Patient characteristics are presented in Table 1. Among this prevalent cohort, a vascular catheter was utilized for HD vascular access in 755 patients (59%) and permanent access (AVF/AVG) was utilized in the remaining 529 patients (41%). Compared to those with a vascular catheter, patients with an AVF/AVG were more likely to be older, male, of larger body size, and of greater dialysis vintage. They also had significantly higher hemoglobin, serum albumin, and spKt/V urea values. The results of a multivariate logistic regression analysis examining the association of selected clinical characteristics with having a vascular catheter (versus an AVF/AVG) for HD access are presented in Table 2.

Examination of Reasons Provided For Use of a Vascular Catheter

Table 3 lists the reasons provided for use of a vascular catheter for HD access. The most commonly listed reason for use of a vascular catheter was “No AVF/AVG created at this time”. Comparing children with this reason to those with any other provided reason for use of a vascular catheter, those with the “No AVF/AVG created at this time” reason were more likely to be older (mean age [standard deviation] 13.9 [3.2] years versus 12.1 [4.5] years, $p<0.001$), of briefer dialysis vintage (mean 13.0 [20.6] months versus 18.2 [28.8] months, $p=0.02$), African American (54.8% versus 46.6%, $p=0.04$), not of Hispanic ethnicity (20.4% Hispanic versus 29.5%, $p=0.009$), and of larger body size (95.2% greater or equal to 20 kg versus 82.7%, $p<0.001$). Patients with this reason provided were as likely to be transplanted during the follow-up period as those with any other reason provided (32.2% transplanted within each group).

The next most common reason was “Patient too small for AVF/AVG”. Table 4 describes the height, weight and body surface area of the patients with this reason listed, and compares these parameters to two other groups: those with a vascular catheter *without* the “patient too small”

reason provided, and those with an AVF/AVG. Comparing those within the “patient too small” category who were less than 20 kg versus greater than or equal to 20 kg, those less than 20 kg were more likely to be male (56.2% versus 49.3%, $p=0.04$) and white (65.7% versus 46.4%, $p=0.02$). No significant differences in dialysis vintage or kidney transplantation during the *entire* follow-up period existed between the two groups. However, those <20 kg were significantly more likely to be transplanted within 1 year compared to those greater than or equal to 20 kg (39.7% versus 23.2%, $p=0.03$).

The “AVF/AVG maturing” reason was provided next most commonly. Among the 110 patients for whom this reason was provided, 53 were present in the next consecutive CPM study year. Of these 53 patients, 19 (35.8%) had a vascular catheter in the next ESRD CPM study year; the remaining 64.3% of patients had a functioning AVF/AVG. Of the 19 patients with a vascular catheter, reasons for a catheter most commonly listed included “AVF/AVG maturing” (36.8%) and “temporary interruption of AVF/AVG” (31.5%).

Among the 33 patients with “temporary interruption of AVF/AVG” reason provided, 23 were present in the next consecutive ESRD CPM study year. Of these 23 patients, 10 (43.5%) had a vascular catheter in the next ESRD CPM study year.

Peripheral vascular disease was uncommonly listed as a reason for use of a vascular catheter. Of the 29 patients with this reason, 12 (41%) had a congenital urologic/renal cause underlying ESRD. Eleven patients (38%) in this group had systemic vasculitis (systemic lupus erythematosus, polyarteritis, or systemic sclerosis) listed as the cause for ESRD.

Transplantation and Length of Time to Transplantation

Of the 1,284 patients examined, 624 (48.6%) were identified within the USRDS as having received a kidney transplant during the available follow-up period through December 2004. Those with a vascular catheter versus an AVF/AVG were more likely to receive a transplant within the first year of follow-up (32.2% versus 21.7%, $p<0.001$). Patients with a catheter were also more likely to be transplanted by December 31, 2004, the end of the follow-up period (53.5% versus 41.6%, $p<0.001$). Among the 83 patients with the “transplant scheduled” reason provided, 57 (68.7%) were transplanted during the first year of follow-up, and 68 (81.9%) were transplanted by the end of the follow-up period. Among those with any other reason for use of a vascular catheter other than “transplant scheduled”, 50% received a transplant during the entire follow-up period. Table 5 describes the length of time to transplantation by type of vascular access, and by reason given for use of vascular catheter,

Access Type at Initiation of Hemodialysis

Of the 1,284 unique patients included within the 2001–2003 ESRD CPM Projects, 445 (34.7%) newly initiated a maintenance course of dialysis between January and August within the three project years examined. These patients more commonly initiated dialysis with a vascular catheter (89.2%) versus an AVF/AVG (8.1%). Of these patients, 85.6% initiated with a catheter in 2001 (Project Year only including children 12–<17 years), 88.6% in 2002, and 88.3% in 2003. Vascular catheter use at initiation was less common in older children: 100% of children aged 0–≥4 years, 95.4% aged 5–≥11 years, 90.7% aged 12–≥15 years, and 84.5% aged 16–<18 years initiated with catheter. Among those initiating HD with a vascular catheter, 76% in 2001, 76% in 2002, and 81% in 2003 had a vascular catheter 90 days after initiation. It was possible to examine the type of vascular access in the consecutive CPM project year for a subset of the incident children with a vascular catheter still in use 90 days after initiating HD. Of this cohort, 59% continued with a vascular catheter as HD access in the following CPM project year. In this subset, the most common reasons listed in the subsequent CPM project year for

use of a vascular catheter included: “AVF/AVG not created” (21%), “patient too small” (17%), “patient preference” (17%), “transplant scheduled” (9%), and “provider preference” (9%).

DISCUSSION

This study illustrates the challenges of vascular access in children with ESRD on maintenance HD, and provides a glimpse into the reasons that may present obstacles to the placement of AVF/AVGs. Despite long-standing evidence that AVF/AVGs are associated with better quality of life and improved outcomes in the adult ESRD population, and increasing evidence that this is also true in the pediatric population, vascular catheters remain the predominant vascular access type in children.

The reasons for the high prevalence of vascular catheters in children on HD might be dichotomized: {1} AVF/AVG not appropriate as patient unlikely to receive HD for an extended period of time, and {2} existence of major barrier(s) to placement of an AVF/AVG. In regards to plans for short-term HD, dialysis is commonly considered a “bridge to transplantation” in children with ESRD. Transplantation is considered the renal replacement therapy of choice for children, and the high rate of transplantation is facilitated by the high prevalence of living donor transplants in this age group. The Scientific Registry of Transplant Recipients’ (SRTR) 2006 Report on the State of Transplantation reports 890 kidney transplants in children age 0 to <18 years old in 2005. Of these, 47.4% were from living donors. In the same year, the median waiting time for a deceased donor kidney for children was less than 300 days. Comparatively, in adult ESRD patients, the median deceased donor waiting time was never less than 920 days from 1996–2005.(23,24) Thus, given the prevalence of living kidney donors, and the relatively short deceased donor waiting times for children, it may be reasonable for clinicians to anticipate that a child may be on HD for a short period of time. In this study, 32.2% of patients with a vascular catheter were transplanted within the first year of follow-up, and 53.5% were transplanted during the entire follow-up period. Among those transplanted within the vascular catheter cohort, the median waiting time was 264 days; 25% of patients had not received a kidney transplant after 492 days. Among the approximately 10% of the catheter population with the “Transplant Scheduled” reason given, the time to transplantation was significantly shorter: the median time was 115 days, and 75% were transplanted by 203 days. Thus, for a subset of the population with catheters, transplantation is truly expeditious. As might be predicted, this is not the case for all patients, which is likely partially explained by the second main reason for a vascular catheter: barriers.

Multiple barriers may exist that may preclude the successful placement of an AVF/AVG in a child, but one of the most common reasons is related to patient size. “Patient too small” was the second most commonly listed reason for use of a vascular catheter in CMS’s ESRD CPM Projects. Patients with this reason listed were significantly smaller than their counterparts as measured by height, weight, and body surface area. Current KDOQI guidelines recommend that AVF/AVG’s be considered for those weighing greater than or equal to 20 kilograms who are expected to wait more than one year for a kidney transplant. In this analysis, almost half of the 142 children described as too small for a permanent access weighed 20 kilograms or more. Of these 69 children, only 16 (23%) received a kidney transplant within one year. Although the 20 kilogram weight suggestion was published after the data collection period for this study, more recent ESRD CPM Projects do not suggest a trend towards decreased prevalence of vascular catheters. The 2006 ESRD CPM Project reports 61% of prevalent pediatric HD patients dialyzed with a vascular catheter, similar to 56% found in the 2002 Project and 57% in the 2003 Project.(25)

Although this study examines one of the largest cohorts of children maintained on HD, limitations exist. The USRDS data are generated from administrative billing data, and follow-

up was truncated on December 31, 2004 due to the nature of release of USRDS data; therefore the possibility exists that some transplant events were not captured. However, as of 1994, all transplant events found in the United Network for Organ Sharing files are incorporated into the USRDS files, likely greatly increasing the capture.(26) By selecting January 1 of each study year as the start of the time-to-transplantation analysis, the actual time to transplantation was likely underestimated in some cases. Given the study question, this was deemed the most acceptable bias. The collapse of the AVF and AVG access categories into a single category limits comparison of these two groups. The ESRD CPM data collection forms are commonly completed by dialysis staff (nurses or social workers). It is possible that staff may not have complete insight into the reasons for use of a vascular catheter. This may explain the high prevalence of the “no AVF/AVG created at this time” reason found in each year of the ESRD CPM Projects. A sub-analysis of the group with this reason found them more likely to be older, of briefer dialysis vintage, African American, and of larger body size.

This study examines data that preceded the 2006 Update of KDOQI Vascular Access Clinical Practice Guidelines, which included pediatric-specific recommendations for the first time.(1) The study also preceded CMS’s “Fistula First” initiative, a quality improvement program announced in 2004 to increase AVF placement in adult HD patients.(27,28) Given the new guidelines and Fistula First initiative, it is possible that vascular access patterns for children on HD have changed in the past few years. Future study will be necessary to evaluate the impact of these guidelines/initiatives. However, the preference for AVF’s, at least for adults, was emphasized around the time of data collection for the present study. Potential quality of care standards to maximize placement of AVF’s were also outlined.

In summary, this study provides a detailed examination of vascular access patterns and the reasons for use of vascular catheters in children on maintenance HD. The high rate of transplantation observed, after a relatively short period of time receiving HD, supports the rationale behind use of a vascular catheter as a “bridge to transplantation” for some children. However, significant numbers of children are not receiving expeditious transplantation, and the reasons for this cannot be fully delineated by these databases. But it is clear that significant barriers to placement and use of AVF/AVGs persist in children maintained on HD. Technical challenges related to body size appear to significantly contribute to these barriers. The data also suggest a significant complication rate of AVF/AVGs in this population. Access to placement, primary failure rate, and longevity of AVF/AVGs for a given region/center cannot be evaluated. Surgical availability, interest and expertise likely significantly contribute to the likelihood of AVF/AVGs being successfully placed. Regardless of the barriers, room for improvement in the achievement of permanent access in children maintained on HD likely exists.(29) Future research should concentrate on better delineating these barriers, so that solutions to overcome them can be considered and implemented. Given that chronic kidney disease is a lifelong diagnosis, and most transplanted patients may return to dialysis based on the current standards of care, children with ESRD warrant careful attention in the area of vascular access.

Acknowledgements

Portions of these data were presented in abstract form at the Pediatric Academic Society Meeting, May 5 to 8, 2007; Toronto, Canada.

Support: This work was supported by National Institutes of Health grant R21-DK-064313 to Dr Furth. Dr. Furth is also supported by a Midcareer Investigator Award (K24-DK-078737). Dr. Fadrowski is supported by a Mentored Patient-Oriented Career Development Award (K23-ES-016514).

Financial Disclosure: None.

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Table 1

Clinical Characteristics of 1,284 Children Receiving Hemodialysis in ESRD CPM Project Years 2001, 2002, and 2003, by Vascular Access Type

	Vascular Catheter (N=755)	AVF or AVG (N=529)
Age (y) [‡] *	12.6 (4.2)	14.8 (2.3)
0–4.9 (%)	53 (7.0)	1 (0.2)
5–11.9 (%)	169 (22.4)	41 (7.8)
12–15.9 (%)	302 (40.0)	223 (42.2)
16–<18 (%)	231 (30.6)	264 (49.9)
Sex (%) *		
Male	50.7	62.4
Race (%)		
White	50.9	47.2
Ethnicity (%)		
Hispanic	26.6	24.2
Cause of ESRD (%)		
Congenital Renal/Urologic	40.7	36.3
Dialysis vintage (mo) *	16.6 (26.7)	25.6 (31.1)
<6 (%)	332 (44.6)	79 (15.1)
6–<12 (%)	195 (26.2)	161 (30.8)
12–<24 (%)	93 (12.5)	119 (22.8)
>24 (%)	125 (16.7)	163 (31.3)
Hemoglobin (g/dL) *	10.9 (1.6)	11.5 (1.5)
Mean hemoglobin <11.0 g/dL (%) *	50.1	28.0
Anemic (%) [§]	73.3	72.9
Mean serum albumin <3.5/3.2 g/dL (%) ^{##}	23.2	13.0
spKt/V urea *	1.52 (0.41)	1.64 (0.91)
Mean spKt/V urea <1.2 (%) *	20.5	9.5
Body surface area (m ²) [£] *	1.33 (0.43)	1.51 (0.40)

Note: Values expressed as percent or mean ± SD unless noted otherwise. Hemoglobin and serum albumin in g/dL may be converted to g/L by multiplying by 10.

Abbreviation: ESRD, end-stage renal disease; CPM, Clinical Performance Measures

[‡] 2001 ESRD CPM Project data collection limited to children aged 12 to <18 years

* $p < 0.001$

[§] hemoglobin less than 5th percentile for age and sex

[#] bromocresol green/bromocresol purple laboratory method

[£] calculated by Mosteller equation (19)

Table 2

Association of Clinical Characteristics With Vascular Catheter As HD Access (versus AVF/AVG) in Children in the 2001–2003 ESRD CPM Projects

	Odds Ratio	95% Confidence Interval
Age category, years (13–<18 versus 0–≥12)	0.32	0.22, 0.47
Dialysis vintage category, months (versus <6)		
6–<12	0.28	0.20, 0.39
12–<24	0.15	0.099, 0.22
>24	0.15	0.11, 0.22
BSA quartile, m ² (versus 1 st quartile)		
2 nd	0.61	0.41, 0.91
3 rd	0.65	0.42, 0.99
4 th	0.53	0.34, 0.82
Male versus female	0.54	0.42, 0.69
White versus African American	1.02	0.79, 1.32
Hispanic ethnicity	1.04	0.77, 1.41

Note: Odds ratios are from multivariate logistic regression

Abbreviations: HD, hemodialysis; AVF/AVG, arteriovenous fistula/graft; ESRD, end-stage renal disease; CPM, Clinical Performance Measures

Table 3

Reasons Provided For Use of Vascular Catheter in 755 Unique Children, ESRD CPM Project Years 2001–2003

REASON	N (%) [*]
No AVF/AVG created at this time	230 (27.9)
Patient too small for AVF/AVG	142 (17.3)
AVF/AVG maturing	110 (13.4)
Transplant scheduled	83 (10.1)
Patient preference [§]	83 (10.1)
Provider preference [§]	48 (5.8)
Temporary interruption of AVF/AVG	33 (4.0)
Other	31 (3.8)
Peripheral vascular disease	29 (3.5)
All AVF/AVG sites exhausted	18 (2.2)
Planned dialysis modality switch/peritoneal dialysis complication [#]	13 (1.6)
Previous AVF/AVG failed	3 (0.3)
Missing	0

Abbreviations: AVF/AVG, arteriovenous fistula/graft; ESRD, end-stage renal disease; CPM, Clinical Performance Measures

^{*} Total N= 823; More than one reason may be provided for a patient; denominator for percent calculation = 823[§] Reason not listed as choice on CPM 2001 data form[#] Reason obtained from “other” write-in description, write-in not allowed on CPM 2001 data form

Table 4
Body Size Parameters By Vascular Access Type/Reason Among 1,284 Unique Children, ESRD CPM Project Years 2001–2003

	I. Vascular Catheter, "Patient too small" Reason N= 142	II. Vascular Catheter, All Other Reasons N= 613	III. AVF/AVG N= 529
Height (cm)			
Mean*	110.8	150.1	154.2
Median	109.1	153.7	157.0
Weight (kg)			
Mean*	22.7	51.6	54.8
Median	20.5	49.5	50.8
<20 kg	73 (51.4%)	29 (4.7%)	12 (2.3%)
≥20 kg	69 (48.6%)	584 (95.3%)	517 (97.3%)
BSA (m ²)			
Mean*	0.83	1.45	1.51
Median	0.80	1.45	1.48

Abbreviation: ESRD, end-stage renal disease; CPM, Clinical Performance Measures; AVF/AVG, arteriovenous fistula/graft; BSA, body surface area

Note: BSA calculated by Mosteller equation: $\sqrt{[\text{ht (cm)} \times \text{wt (kg)}]/3600}$

*
p value for means all <0.001 comparing I vs II and I vs III

Table 5

Length of Time to Transplantation (Days) by Type of Vascular Access and Reason for Vascular Catheter, ESRD CPM Project Years 2001–2003

	I. Vascular Catheter, All Patients N= 404	II. AVF/AVG N= 220	III. Vascular Catheter, “Transplant Scheduled” Reason N=68	IV. Vascular Catheter, All Other Reasons N= 336
Mean (SD) *	330 (260)	429 (318)	163 (167)	364 (262)
Median	264	347	115 35	307
25 th Percentile	126	176		156
75 th Percentile	492	629	203	534
Maximum	1324	1298	623	1324

Abbreviation: ESRD, end-stage renal disease; CPM, Clinical Performance Measures; AVF/AVG, arteriovenous fistula/graft

* *p* value for mean days <0.001 comparing I vs II, and III vs IV