

Pediatric Fistula Initiative: Reducing Bloodstream Infections in an Outpatient Pediatric Hemodialysis Center

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Bloodstream infection is a major contributor to morbidity and mortality in children on hemodialysis (HD). From January 2009 through April 2011, the incidence of access-related bloodstream infections (ARBs) in pediatric patients on HD at our hospital was 3.45/1000 patient days. Almost all of these children were receiving HD via central line catheters, and none were receiving HD via arteriovenous fistulas (AVFs). In an effort to reduce the rate of infection in children receiving HD at our institution, we introduced the Pediatric Fistula Initiative, a program to increase creation and use of AVFs in children. Thirty-three children on HD were observed, 9 of whom received AVFs during the study period. The incidence of ARBs decreased to 1.30/1000 patient days ($P < .001$) during the 24-month intervention period from May 2011 through May 2013.

Key words. access-related bloodstream infections; arteriovenous fistulas; catheter-related bloodstream infections; CRBSIs; hemodialysis; Pediatric Fistula Initiative.

The prevalence of end-stage renal disease in children in the United States was 86 per million in 2010 [1]. Thirty-eight percent received a transplant within the first year of diagnosis [1, 2]. Hemodialysis (HD) remains the most common mode of long-term dialysis, accounting for 62% [1]. Vascular access-related infections are a significant cause of hospitalization and are associated with significant morbidity and mortality. In the United States, hospital-acquired vascular access-related infection has declined overall but not in patients receiving outpatient HD [3]. Central vascular catheters (CVCs) are associated with higher rates of infections compared with arteriovenous fistulas (AVFs) or arteriovenous grafts (AVGs) [4–6]. The US Fistula First National Vascular Access Improvement Initiative was successful in increasing AVF use in adults; however, the initiative has not had an impact on children [7]. In 2006, the National Kidney Disease Foundation Kidney Disease Outcomes Quality Initiatives (NKF KDOQI) has provided vascular access guidelines suggesting serious consideration to placement of AVF in children who weighed more than 20 kg and require HD and who

are likely to wait longer than 1 year for transplantation [4]. The International Pediatric Fistula First Initiative: A Call to Action has provided vascular access guidelines that suggest fistula use in long-term pediatric HD patients [8]. However, there is currently a lack of evidenced-based guidelines for HD vascular access in children in the pediatric nephrology community, and the United States continues to preferentially use CVCs as a method of vascular access [9]. Arteriovenous fistula use in long-term pediatric HD patients remains less than 20%. Central vascular catheters remain the most common form of vascular access in children and their use has been increasing [1]. Arteriovenous fistula creation in children can be challenging in a facility where there is no pediatric vascular surgeon, as is common in many pediatric dialysis centers including ours. The most common cause of chronic kidney disease of children is congenital abnormalities of the kidney and urinary tract (CAKUT) [1]. Those children often depend on renal replacement therapy soon after birth. Most children have exhausted their veins from prior failed vascular access, including central vascular thrombosis or stenosis. In fact,

children younger than 10 year of age had the highest rate of access-related infection [1]. However, it was unclear whether AVF as primary vascular access for HD in this age group resulted in a better outcome. There are several reasons for this observation. Many children had expeditious transplantation, and AVF creation in young children is highly specialized and technically difficult [4, 10]. Primary failure rates as high as 20%–50% have been reported [2, 11, 12]. Arteriovenous fistula maturation can also take up to 4 to 6 months. Peritoneal dialysis is the preferred modality of dialysis in this age group and can be used as a bridge to transplantation. To address the prevention of access-related bloodstream infections (BSIs) in pediatric outpatient HD, in April 2011 we implemented the Pediatric Fistula First Initiative to emphasize the current vascular access guidelines, increased patient-parent education, and AVF creation when possible and appropriate.

METHODS

Patients were all children, ages 0–21, who received HD at the pediatric outpatient HD center at SUNY Downstate Medical Center from January 2009 to April 2013. SUNY Downstate Medical Center has a 5-station, hospital-based outpatient HD center serving patients in Brooklyn, New York. Patient data collected included demographic information, cause of renal failure, mode of vascular access, and complications of vascular access. The Pediatric Fistula First Initiative is a multidisciplinary team consisting of pediatric nephrologists, adult vascular access surgeons, and pediatric infectious disease specialists to increase the creation and use of AVFs in children. Program members participated in monthly meetings that served as a forum for stressing the importance of the use of AVF for HD vascular access, they reported monthly incidence of HD access-related infections and access-related complications, and they identified and evaluated candidates for AVF creations. The referral candidates for AVF creation were all children in dialysis center who had a weight >20 kg and on chronic hemodialysis via CVC and who were not on active transplant list. Venography was performed to assist in all AVF placements, which were considered when vein diameter was ≥ 3 mm. Creation of the fistula was preferred to be on the nondominant arm or side contralateral to the CVC and at a time when the patient was free from infection for more than 8 weeks. Every patient with AVG/AVF was evaluated by a vascular surgeon every 6 months. Before introduction of the program, the facility complied with guidelines for the preventing intravascular catheter-related infections [13].

An access-related bloodstream infection (ARB) was defined by previously published criteria [14, 15] as either a positive semiquantitative catheter tip culture (>15 colony-forming units per catheter segment rolled on a culture plate) yielding the same microorganism recovered from a peripheral vein or at least 2 positive blood cultures of common commensal or at least 1 positive blood culture of known pathogens such as candida spp, with clinical manifestation of infections and no other apparent source of infection than the access. A patient was not considered to have a second episode if a positive blood culture occurred within 21 days after a previous blood culture event in the same patient. Rates of ARBs were evaluated in the preintervention (January 2009–April 2011) and intervention period (May 2011–May 2013).

A Fisher's exact test was used to compare categorical data, measuring the association between 2 variables. An incidence rate ratio was used to compare preintervention infection rate with intervention infection rate. All data were analyzed using SPSS.

RESULTS

Thirty-three children (17 males, age 2–21 years, median 17 years) received dialysis treatment at the facility during the study period (January 2009–May 2013). Renal failure was secondary to CAKUT in 16 patients, focal segmental glomerulosclerosis in 2, glomerulonephritis secondary to vasculitis in 7, other glomerulonephropathies in 3, and other causes in 5. Twenty-six children had received dialysis treatment during the preintervention period: none via AVF, 2 of 26 (9%) via AVG, and 24 of 26 (91%) via CVC. Twenty-four of 26 children had received dialysis treatment at the time the program was introduced in April 2011, 2 of 26 had transplantation before initiating the program, and 7 children were started on HD during the implementation of the program (all by CVC).

Access-related bloodstream infection episodes in children ranged from 0 to 14 per patient (median 1), and 3 patients had 10 or more ARB episodes during the study period. The incidence of all ARBs decreased from 3.45 per patient/1000 days preintervention to 1.30 after initiating program interventions ($P < .001$) (Table 1).

Thirty-one patients were receiving HD during intervention period, 29 patients have had CVC use, 11 were not candidates for AVF, 5 of 11 were too small (2–5 years old, weight <15 kg), 5 of 11 had transplant scheduled, and 1 anticipated having cannulation difficulties due to an underlying neurological condition. Eighteen children were referred for AVF creation, 9 patients had completed AVF creation during the intervention period (all 2 stage

Table 1. Incidence Rate of All Vascular Access-Related Blood Stream Infections in an Outpatient Pediatric Hemodialysis Center

Period	Number of Patients	Patient-Days	AVF Use N (%)	CVC Use N (%)	P Value	ARB (number of episodes)		Incidence Rate (per 1000 patient-days)	Incidence Rate Ratio (95% CI)	P Value
						AVF	CVC			
Preintervention (January 2009–April 2011)	26	14 199	0 (0%)	24 (92%)	.006	N/A*	49	3.45	Referent	Referent
Intervention (May 2011–April 2013)	31	13 897	4 (26.7%)	10 (66.7%)		0	18	1.3	0.38 (0.05–2.86)	<.001

Abbreviations: ARB, access-related bloodstream infection; AVF, arteriovenous fistula; CI, confidence interval; CVC, central vascular catheters; N/A, not applicable. *AVFs were not in use during the preintervention period.

procedures: 89% brachiocephalic and 11% saphenofemoral), 2 were scheduled for AVF creation, and 7 refused because of concern for physical appearance of fistula. Among 7 patients who refused, 3 eventually received transplants, 2 moved out the area, and 2 continued using CVC for HD to the end of the study. One child had an AVF created 6 months after the study was completed. At the end of the study, of the 15 patients who received HD, 4 (27%) were via AVF, 1 (7%) was via AVG, and 10 (67%) were via CVC. Fifteen of 33 (45%) patients were eventually transplanted.

The average time from referral to placement was 1.2 months. The average time from creation to cannulation was 2.4 months. The complications were early maturation failure for cannulation (11%), focal stenosis requiring angioplasty (22%), thrombosis (44%), and pseudoaneurysm (11%), and successful surgical thrombolysis and angioplasty was performed in those who had stenosis or thrombosis except in 1 patient.

All CVCs were in internal jugular vein, with the exception of 1 patient who temporally had CVCs in femoral vein due to exhaustion of veins in upper extremities. Complications related to catheter-infections included 4 episodes of thrombosis or stenosis (1 superior vena cava syndrome, 2 inferior vena cava occlusions, and 1 brachiocephalic deep vein thrombosis), 2 endovascular infections, and 1 septic arthritis of bilateral hips. Fifty episodes of infection required catheter exchange, and 2 patients had complications related to anesthesia, of which 1 had hypoxic ischemic brain injury and died and 1 had severe bradycardia and hypotension.

DISCUSSION

Our study demonstrated that a formal program of implement creation and use of AVFs significantly decreased infection rate and infection-associated complications in children who required prolonged dialysis, particularly in children who started HD at a younger age and had comorbidities preventing transplantation or failed transplantation. One of our patients required dialysis at the age of 4 years and had been removed from the transplantation list due to frequent femoral HD catheter-related BSIs (25 episodes over a 5-year period). A femoral artery to saphenous vein AVF was created. This type of fistula is rarely used, but the veins in the patient’s upper extremities were exhausted from long-standing HD (8 years). At the end of the study, she became infection free and was successfully transplanted.

The rates of ARBs in our preintervention period (3.45 per patient/1000 day) were comparable with previous reports [16–20]. There have been no reports of large population-based ARB rates in children on HD. Access-

related bloodstream infections and access-related complications are known to be age-related and are especially high in infants and young children. Previous studies had shown CVC-related infections in children ranging from 0.5 to 4.8 per 1000 catheter days [16–20]. The estimated ARBs rate in HD pediatric and adult patients with central line in 2008 was 1.05 per 1000 central line days [3]. The incidence rate of ARBs also varied due to the inconsistency of ARB definition among previously published reports. The definite diagnosis of ARB has been proposed by at least 3 major work including the Centers for Disease Control and Prevention, and Public Health Agency of Canada. Despite specific guidelines, investigators frequently use their own criteria. This is mainly due to unavailability of catheter tips for culture and quantitative blood culture in most microbiology laboratories.

This study does have some limitations. The experience was limited to a single center with a relatively small sample size. However, implementation of the Pediatric Fistula Initiative significantly decreased the rate of ARBs and prevented associated complications in children undergoing HD in our institution. The Fistula Initiative can be applied to the pediatric populations in the setting of adult vascular surgeons with single center experience. Increased efforts should be made to use AVF in children undergoing long-term HD.

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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