Comparison of Arteriovenous Fistulas and Arteriovenous Grafts in Patients with Favorable Vascular Anatomy and Equivalent Access to Health Care: Is a Reappraisal of the Fistula First Initiative Indicated?

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BACKGROUND: Initiatives to increase arteriovenous fistula (AVF) use are based on studies that show that AVFs require fewer interventions and have better patency than arteriovenous grafts (AVGs). Because patients who receive AVFs typically have more favorable vascular anatomy and are referred earlier for access placement than those who receive AVGs, the advantages of AVF might be overestimated. We compared outcomes for AVFs and AVGs in patients with equivalent vascular anatomy who were on dialysis via catheter at the time of vascular access placement.

STUDY DESIGN: The study included patients who underwent placement of a first-time AVF or AVG between 2006 and 2009, who were on dialysis via catheter at the time of access placement, and who had favorable arterial and venous (>3 mm) anatomy. Outcomes for AVF and AVG were compared.

RESULTS: Eighty-nine AVF and 59 AVG patients met study inclusion criteria. Similar secondary patency was achieved by AVG and AVF at 12 (72% vs 71%) and 24 months (57% vs 62%), respectively ($p = 0.96$). The number of interventions required to maintain patency for AVF ($n = 1$; range 0 to 10) and AVG ($n = 1$; range 0 to 11) were not different ($p = 0.36$). However, the number of catheter days to first access use was more than doubled in the AVF group (median 81 days) compared with the AVG group (median 38 days; $p < 0.001$).

CONCLUSIONS: For patients who are receiving dialysis via catheter at the time of access placement, the maturation time, risk of nonmaturation, and interventions required to achieve a functional AVF can negate its benefits over AVG. A fistula first approach might not always apply to patients who are already on dialysis when referred for chronic access placement. (J Am Coll Surg 2013;216:679–686. © 2013 by the American College of Surgeons)

Major efforts have been made during the past decade to increase arteriovenous fistula (AVF) use in the United States. Such efforts are based on a substantial body of literature that indicates risks of infection, thrombosis, and death and overall health care costs are lower for patients with AVF as compared with those with arteriovenous grafts (AVGs).[1-7] Widespread acceptance of such benefits by the scientific community prompted the Centers for Medicare and Medicaid Services in 2003 to launch the Fistula First Breakthrough Initiative (FFBI). This initiative developed specific strategies to increase AVF use and established benchmarks that would achieve a national AVF prevalence rate of 66% by 2009. Currently, the AVF prevalence rate in the United States is approximately 61%.[8] To increase this rate, the Centers for Medicare and Medicaid Services plan to establish

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a pay-for-performance program beginning in 2014 that will cut reimbursement to dialysis units not meeting their set benchmarks.

The notion that creation and use of AVF are indicated in nearly all clinical scenarios has been based largely on nonrandomized studies that compare outcomes of AVF and AVG. These studies, however, rarely control for factors that could bias outcomes in favor of AVF. For example, patients who receive AVGs are more likely to be those with diabetes mellitus, peripheral artery disease, and the elderly; factors that are well known to adversely affect access outcomes.[9] Quality of the vascular anatomy and an individual patient's access to health care are 2 other variables that could bias the conclusions of studies comparing AVF and AVG outcomes. Patients who undergo AVF creation often have more favorable vascular anatomy than patients who receive AVG placement because of the concern that maturation is unlikely to occur in patients with disadvantaged anatomy. In addition, patients chosen for an AVF are more likely to be referred to a surgeon well in advance of their need for hemodialysis to allow time for access maturation, and patients who undergo AVG placement are far more likely already to be on dialysis via catheter. Social factors, such as better access to health care, could explain why patients who undergo AVF creation are referred earlier for access placement. Such social differences could possibly favor AVF when comparing outcomes.

The purpose of the current report was to compare primary AVF and AVG outcomes in patients with favorable vascular anatomy and with equivalent access to health care services.

METHODS

This study was approved by the Institutional Review Board of the Greenville Hospital System/University Medical Center. The Greenville Hospital System/University Medical Center Department of Surgery Vascular Access database was retrospectively reviewed to identify all patients who underwent first-time AVF creation or AVG placement between July 2006 and December 2009. Hospital and dialysis center records were reviewed to identify which of those patients were receiving hemodialysis via cuffed dialysis catheter at the time of their initial access placement or creation. Operative reports and preoperative vein mapping were used to identify and exclude all patients with poor vascular anatomy, as defined by the presence of substantial occlusive arterial disease at the site of the arterial anastomosis, veins measuring <3 mm on preoperative mapping, or small and/or sclerotic veins identified at operation. Additional patient demographic information and outcomes data were gathered through review of operative reports, outpatient office visits, dialysis clinic notes, hospital records, and the Social Security Death Index.

The initial date used to calculate primary and secondary patency was not the date of vascular access creation or placement, but rather the date of first successful access use. Functional primary patency was calculated as the time from date of first use of the access until date of the first procedure to maintain or restore functional patency, or the date of permanent failure. Functional secondary patency was calculated from date of first use to date of permanent failure. Accesses that failed before were considered immediate failures. Adjunctive procedures performed to achieve access maturation, such as the second stage of a brachial-basilic transposition, were not used to calculate primary patency. Patient survival was calculated from date of the initial access creation or placement to date of patient death. The number of interventions required to achieve and maintain vascular access functionality was determined.

Continuously distributed data were evaluated using the independent samples *t*-test and categorical data were evaluated using Fisher's exact test. Functional patency as well as survival were estimated using Kaplan-Meier life-table methods, with the log-rank test used to determine differences between groups. For all analyses, statistical significance was assessed at $\alpha = 0.05$.

RESULTS

During the study period, 201 (114 AVF and 87 AVG) patients underwent first-time AVF creation or AVG placement when on dialysis via tunneled, cuffed dialysis catheter at the time of their access surgery. Fifty-three (26%) of these were excluded from the study (25 AVF [22%] and 28 AVG [32%]); 19 patients because of poor vascular anatomy; 4 because of inadequate documentation of vascular anatomy in the medical record (no preoperative vein mapping and no comments related to the vascular anatomy in the operative report); 10 had inadequate follow-up; and 5 because improvement of their renal function allowed discontinuation of hemodialysis after access placement. There were 15 deaths before access use. Overall, 148 patients (89 AVF and 59 AVG) met study criteria and became the study population. Access type and location are shown in Table 1. Mean patient follow-up was 21.4 months (median 16.5 months). A comparison of patient demographics and comorbidities among the study cohorts are presented in Table 2. Patients in the AVG group were older and more commonly female than those in the AVF

Table 1. Vascular Access Anatomic Location

	Arteriovenous fistula		Arteriovenous graft		
Anatomic location	**n**	**%**	**n**	**%**	**p Value**
Brachial-brachial	0	0	30	51	<0.001
Brachial-basilic	17	19	13	22	
Brachial-cephalic	42	47	12	20	
Radial-brachial	0	0	3	5	
Radial-basilic	1	1	0	0	
Radial-cephalic	28	32	1	2	
Ulnar-basilic	1	1	0	0	

group ($p < 0.05$). Comorbidities were not significantly different between the 2 groups.

Twenty-six percent (23 of 89) of the AVFs failed to mature. Of those that did, 36% (24 of 66) needed at least one adjunctive procedure to achieve maturity. Median number of days from access creation or placement to access use was 81 for the AVF group and 38 for the AVG group ($p < 0.001$).

Functional primary patency tended to favor the AVF group at both 12 (46% vs 23%) and 24 months (41% vs 10%; log-rank $p = 0.06$); however, functional secondary patency estimates were similar (71% vs 72% at 12 months; 62% vs 57% at 24 months; log-rank $p = 0.96$) for AVF and AVG, respectively (Figs. 1, 2). Median number of interventions required to achieve these functional secondary patency rates did not differ between groups (AVF, $n = 1$; range 0 to 10 vs AVG, $n = 1$; range 0 to 11; $p = 0.36$).

Consistent with the baseline difference in age, postoperative survival favored the AVF group (72% vs 50% and 56% vs 32% at 24 and 48 months, respectively; log-rank $p < 0.01$; Fig. 3). Causes of death are presented in Table 3. Two access-related complications occurred in the AVF group. Both deaths resulted from complications associated with dialysis catheters (catheter-related sepsis and pulmonary artery injury during catheter placement) when awaiting AVF maturation. No access-related complications occurred in the AVG group.

DISCUSSION

Most clinicians agree that AVF is superior to AVG, although the relative degree of that benefit is poorly defined in the vascular access literature. This lack of clarity on the issue is a result of many patient factors, such as sex, diabetes mellitus, and vascular anatomy, which influence AVF maturation and its patency. Therefore, patient selection plays a major role in outcomes reported by series comparing AVF and AVG. A systematic review with meta-analysis of 83 studies, comprising nearly 70,000 patients, that AVFs are associated with less risk of death and access-related infection, as well as better patency rates than AVG. However, that study also concluded that literature supporting AVF superiority is low quality and heterogeneous and that selection bias of the vascular access literature likely overestimates the benefit to patients who receive AVF.[2] The majority of studies in that meta-analysis were published well before the FFBI. More recent studies suggest that the increase in AVF prevalence has occurred at the expense of declining AVF maturation. Reported rates of nonmaturation in recent series range from 25% to 60%.[10-14] Although adjunctive procedures can salvage some nonmatured AVFs, such additional procedures increase the morbidity and cost associated with AVFs and can decrease their long-term patency.[15] As AVF creation is expanded to older and sicker patients in an effort to increase "dictated" prevalence, the modest benefits of AVF over AVG might be negated. Accordingly, there is a need for comparative vascular access studies that control specific factors influencing outcomes to establish the relative benefit of AVF in certain populations.

Vascular anatomy and patient access to health care are also potential sources for selection bias in those reports comparing vascular access outcomes. Because most vascular access surgeons recognize the obvious benefits of AVF over AVG, they are more prone to create an AVF for patients who have suitable vascular anatomy and a reasonable opportunity for maturation. Patients with poorer vascular anatomy, such as small veins or peripheral artery disease, are far more likely to have AVG placement because of concern that if an AVF is created it will not mature. Choice of an AVF in patients with marginal vascular anatomy is even less likely if they are already on dialysis via catheter at the time of surgical referral. Retrospective studies comparing AVG and AVF outcomes that do not account for such bias can disadvantage AVG outcomes. Our study corrects for this potential bias by including patients with favorable vascular anatomy only. Early surgical referral for access placement is another factor more common among patients who receive AVF. Early referral to a surgeon for access placement is strongly encouraged by the National Kidney Foundation-Kidney Dialysis Outcome Quality Initiative and the FFBI. However, in 2010, only 18% of patients in the United States had a functioning or maturing access on initiation of hemodialysis.[1] Social factors, such as greater access to health care services, better patient compliance, or higher socioeconomic status, can determine whether there is a functional access in use before starting hemodialysis.[16] To control for the potential influence of these social factors on access outcomes, our study

Table 2. Patient Demographics and Comorbidities

Patient demographics and comorbidities	Arteriovenous fistula	Arteriovenous graft	p Value
n	89	59	
Age, y, mean ± SD	52 ± 16	64 ± 14	<0.001
Sex, n (%)			
Female	30 (34)	35 (59)	0.003
Male	59 (66)	24 (41)	
Race, n (%)			
African American	40 (44)	31 (53)	0.173
Caucasian	44 (49)	28 (48)	
Hispanic	5 (6)	0 (0)	
Diabetes mellitus, n (%)	52 (58)	32 (54)	0.735
Hypertension, n (%)	75 (84)	56 (95)	0.065
COPD, n (%)	12 (14)	15 (25)	0.083
Coronary artery disease, n (%)	28 (32)	22 (37)	0.483
Hyperlipidemia, n (%)	42 (47)	25 (42)	0.615
Statin use, n (%)	21 (24)	9 (15)	0.297
Peripheral arterial disease, n (%)	11 (12)	7 (12)	1.000
Side, n (%)			
Left arm	64 (72)	39 (66)	0.471
Right arm	25 (28)	20 (34)	

only included patients who were already receiving catheter-based hemodialysis at the time of their vascular access placement. Once a patient begins hemodialysis in our community, nephrologists assume a major role in primary care of the patient, seeing the patient on a weekly basis in the dialysis unit and making subspecialty referrals when needed.

Although our study showed a trend toward improved functional primary patency in the AVF group, the difference did not achieve statistical significance. Also, there was no difference in the functional secondary patency between AVG and AVF at 2 years. The most surprising

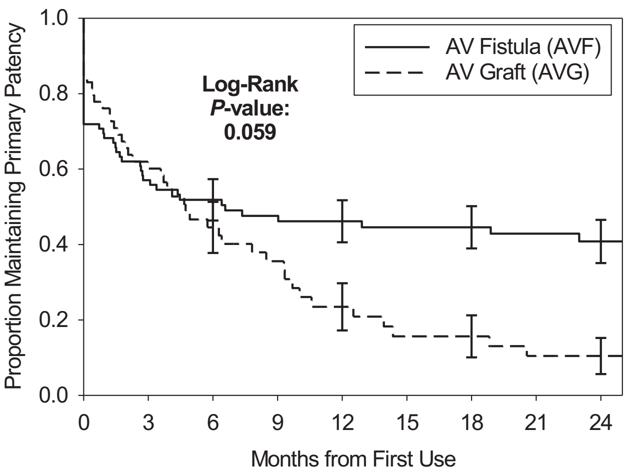

Figure 1. Primary patency of arteriovenous (AV) fistula vs AV graft.

finding of our study was that the number of interventions required to achieve similar patency rates over the life of the access in the AVF and AVG groups was not different. Several reports have suggested that AVGs require more interventions and, accordingly, are associated with both greater cost and morbidity than AVFs.[7,17] This premise was a major driver of the recommendation by the National Kidney Foundation-Kidney Dialysis Outcome Quality Initiative that AVFs are preferable to AVGs, yet that conclusion might not be valid in all clinical situations.[18] If confirmed by other studies, our results would challenge the assumption of the FFBI that increases in AVF prevalence in the United States will necessarily decrease the morbidity and cost associated with vascular access.

In the current study, 26% of AVFs failed to mature, which compares favorably with contemporary series reporting AVF outcomes.[10-14] Our result is attributable to careful patient selection and liberal use of adjunctive procedures to salvage nonmaturing AVF. Although the factors that influence the outcomes of AVF and AVG are the same, some patients might have favorable vascular anatomy for an AVG, but poor anatomy for an AVF. In our study, the majority of patients in the AVG group had an adequate brachial or axillobrachial vein for AVG placement, yet lacked a satisfactory cephalic or basilic vein for AVF creation. Had we expanded our indications for AVF creation to patients with less suitable vascular anatomy in an effort to increase our AVF prevalence, it is likely that

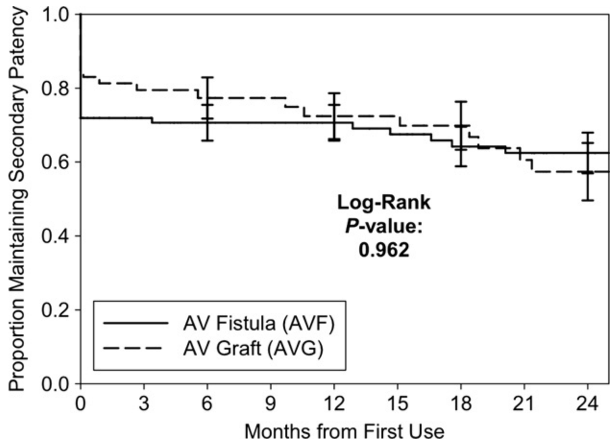

Figure 2. Secondary patency of arteriovenous (AV) fistula vs AV graft.

the nonmaturation and duration of catheter-based dialysis would have increased, patencies would have decreased, and the AVF group would not have fared as well as the AVG group overall.

Proponents of increasing AVF prevalence in the United States point to epidemiologic studies that show survival rates are lower for patients who receive an AVG as compared with those who are given an AVF.[3-5] Our study did show reduced survival rates for patients in the AVG group. However, we believe that the survival difference noted between groups in our study is not a direct result of access type but rather factors related to differences in patient selection. Patients in the AVG group were considerably older than those in the AVF group. Although our analysis showed no statistical difference in comorbidities between study groups, such an analysis only reports whether a comorbidity is present, not the extent or medical control of those comorbidities. In addition, our study only identified 2 access-related deaths, both of which occurred as a result of dialysis catheter complications when awaiting AVF maturation. Whether the difference in survival between patients who receive AVG and AVF is due to the graft or due to patient selection, as suggested by our results, is an important issue that needs additional research.

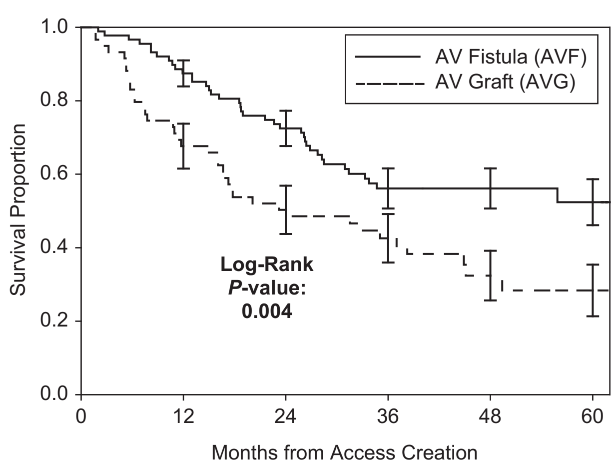

Figure 3. Survival of patients who received arteriovenous (AV) fistula vs AV graft.

Table 3. Causes for Patient Death

	Arteriovenous fistula	Arteriovenous graft
Deaths, n (%)	39/89 (44)	39/59 (66)
Cardiovascular, n	9	10
Complication of ESRD/dialysis, n	9	13
Pulmonary disease, n	7	0
Cancer, n	3	4
Non−access-related sepsis, n	2	2
Access-related death,* n	2	0
Other,† n	5	5
Unknown, n	2	5

*Catheter-related sepsis when awaiting arteriovenous maturation (arteriovenous fistula; n = 1); innominate vein injury during catheter placement when awaiting arteriovenous fistula maturation (n = 1).
†Endocarditis (arteriovenous fistula group, n = 1; arteriovenous graft group, n = 1), liver failure, colitis, sarcoidosis, intracranial bleed from aneurysm, subarachnoid hemorrhage, and failure to thrive.
ESRD, end-stage renal disease.

Outcomes of AVG are influenced by the same patient characteristics and anatomical factors as AVF. A recent multicenter trial sponsored by the National Institutes of Health evaluated the effect of dipyridamole and aspirin on AVG patencies.[19] This study provides a contemporary picture of AVG outcomes since the implementation of the FFBI. The primary patencies at 1 year for the study and placebo groups were 28% and 23%, respectively, which are considerably less than the primary patency of 41% achieved in the current study. In contrast to our study, which targeted patients with favorable vascular anatomy only, theirs included a preponderance of patients at high risk for failure, including those with peripheral vascular disease. As the population of patients who undergo AVF creation is expanded to include patients with less suitable vascular anatomy, and AVG placement is relegated to high-risk patients only, the outcomes for both AVF and AVG might worsen.

Some limitations to our study merit consideration. Because this is a retrospective review, we did not control for important factors that influence vascular access outcomes other than vascular anatomy and patient access to health care. In addition, our use of catheter-based dialysis at the time of access placement as an inclusion criterion to control for health care access differences among patients might not be the most accurate method for control of this variable. Alternative methods to control for variance in health care access might include a determination of a patient's socioeconomic or health insurance status during the predialysis period. However, because these patients received Medicare funding after starting dialysis, and nephrologists address their medical needs on a weekly basis in the dialysis unit, we believe our method reliably controls for potential variations in health care access.

CONCLUSIONS

One should not conclude from our study that the outcomes for AVF and AVG are equivalent and that efforts by the FFBI to increase AVF prevalence should be terminated. Multiple factors affect vascular access outcomes. Our study controlled for only 2 of those factors: vascular anatomy and patient access to health care services. However, our study does highlight the impact of patient selection on vascular access outcomes. It shows that for patients with ideal vascular anatomy on dialysis via catheter at the time of access placement or creation, the benefits of AVF over AVG are negated by the AVFs that fail to mature, by the added interventions on AVFs needed to achieve maturation, and by the additional period of catheter-based dialysis required when awaiting maturation. Accordingly, careful patient selection in terms of both access type and site are crucial to realize the apparent advantages of an AVF. Unfortunately, evidence-based algorithms to determine the most appropriate access procedure are not available. To develop such algorithms, well-designed studies comparing AVF and AVG that control for patient-specific factors that influence outcomes are needed. Without these algorithms, efforts by the FFBI to increase AVF prevalence in the general hemodialysis population, rather than in specifically identified patients better suited for AVF, are unlikely to result in improved patient outcomes and could potentially diminish outcomes.

Author Contributions

Study conception and design: Cull

Acquisition of data: Disbrow, Yang, Keahey

Analysis and interpretation of data: Disbrow, Cull, Carsten, Johnson

Drafting of manuscript: Disbrow, Cull

Critical revision: Disbrow, Cull, Carsten, Yang, Johnson, Keahey

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Discussion

DR THOMAS HUBER (Gainesville, FL): Over the past 2 decades, access surgeons have felt a tremendous amount of pressure from the national initiatives to create autogenous arteriovenous accesses or fistulas based on their perceived benefits. These initiatives have been largely successful and currently, 60% of the patients in our country dialyze with a fistula. However, there has been an impression that this overzealous emphasis and the national targets may not be realistic and may actually be detrimental in terms of the number of remedial procedures required to facilitate fistula maturation and the requisite associated catheter time. Dr Cull and his colleagues have attempted to compare the outcomes of arteriovenous fistula and grafts in a very select group of patients with favorable anatomy and dialyzing with a tunneled catheter. They found that the primary and secondary functional patency rates were comparable, although the primary rates approach statistical significance. The number of remedial procedures required to maintain patency were comparable, although the duration of catheter time before initiation of dialysis was longer in the fistula group. Based on these findings, they concluded that fistulas and grafts were comparable in this select patient group.

Although I am reluctant to challenge Dr Cull's conclusions given his expertise, I would contend that the study must be interpreted with some caution given the retrospective design, relatively small sample size, and the inherent selection biases. Furthermore, I don't think that the results should be used to derail the national initiatives because almost all access surgeons and nephrologists would concede that a mature fistula is the optimal choice. The results can be used to emphasize that the collective goal is not necessarily an arteriovenous fistula, but rather a complication-free functional access and that the specific choice may be different for different patient populations with specific roles for fistulas, grafts, and even catheters. I have 3 questions for the authors.

First, the patency rates were defined from the start of cannulation rather than the time of access creation. This is somewhat nontraditional for most vascular surgical procedures and may actually bias the results in favor of the fistulas. Could you please clarify your patency definitions?

Second, it is not clear in the study why patients with favorable anatomy for a fistula underwent a graft. Could you please detail your selection criteria for both fistulas and grafts, not just in the select patient population of the study, but also in your larger clinical practice?

Finally, future pay for performance standards will be tied to achieving benchmarks in the dialysis units, including the fistula rates. Can you please provide your insights into how we should respond to the nephrologists when they mandate that we create fistulas rather than grafts?

DR MELLICK SYKES (San Antonio, TX): For better or worse, the Fistula First Initiative has dominated the hemodialysis access world for the last decade (Fistula First Breakthrough Initiative: targeting catheter last in fistula first. Vassalotti JA, Jennings WC, Beathard GA, et al and the Fistula First Breakthrough Initiative Community Education Committee. Semin Dialysis 2012;25:303−310). An enthusiastic Centers for Medicare and Medicaid Services (CMS)-sponsored amalgam of administrators, nephrologists, nurses, and statisticians, evangelically dedicated to the single goal of increased arteriovenous (AV) fistula use, Fistula First has become a case study in unintended adverse consequences and the difficulty we all face accepting data that disagree with dogma.

Surgeons, although "crucial" to the Fistula First, seem not to have been fully trusted partners; a condescending tone has crept into recent official publications. This year's Position Paper, for example, opines that, "the nephrologist must be the leader of the vascular access team"; that surgical training in AV fistula formation is "modest or even lacking" in many institutions; and that surgeons find it "difficult to remain current in new concepts, procedures, and technologies in hemodialysis vascular access." Despite efforts of the Fistula First Initiative to reverse the "low priority status of vascular access" among surgeons and educate surgeons in the supremacy of AV fistulas, "… much more work lies ahead."

Although Fistula First's focus on this single metric has indeed moved the fistula prevalence rate toward the arbitrary 66% goal, unintended effects include the marginalization of surgical judgment, the only-slightly-less-than-ideal AV graft abandoned in favor of unpredictable fistula maturation and prolonged catheter use, a costly industry of access centers for intervention on the nonmaturing fistula, and an epidemic of chronic catheter complications.

Conscientious surgeons have battled awkwardly to fit the square peg of Fistula First and CMS expectations into the round hole of the individual dialysis patient's needs and anatomy. The advantages of a fistula are erased by its overuse. It seems time to abandon fistula prevalence as the sole metric of competence in this field. Fistula First may need a new name, or reassessment of its mission.

In this context, I feel Dr Cull and his associates in Greenville are to be congratulated for this work. Their paper suggests clinical equipoise between graft and fistula in the setting of a patient already undergoing catheter dialysis, reinforces the primacy of clinical judgment in this complicated patient population, and restores the option of appropriate AV graft placement to our armamentarium in a field that needs many weapons. Questions: What is your current access algorithm? And why did your grafts take so long to be cannulated?

DR RUTH BUSH (Temple, TX): Dr Cull, your group continues to be leaders in vascular access management. Those of us who do vascular access, as Dr Sykes says, understand the reality facing us with the National Kidney Foundation Kidney Disease Outcomes Quality Initiative and pay-for-performance, and that the people writing these guidelines don't necessarily see the surgical reality.

I have 1 simple question. One data point I did not see was body mass index or weight. This patient-level variable tends to be, I suspect, in South Carolina the same as it is in Texas, in that it requires multiple procedures to get a fistula to work so that the dialysis centers can cannulate it: superficialization, transposition, or lipectomy, fat removal. Would you please comment?

DR MARC MITCHELL (Jackson, MS): The important question concerns the total number of catheter days. Did you look at the